FATTER PIPES: 6GHz Wi-Fi 6E IS HERE

apc

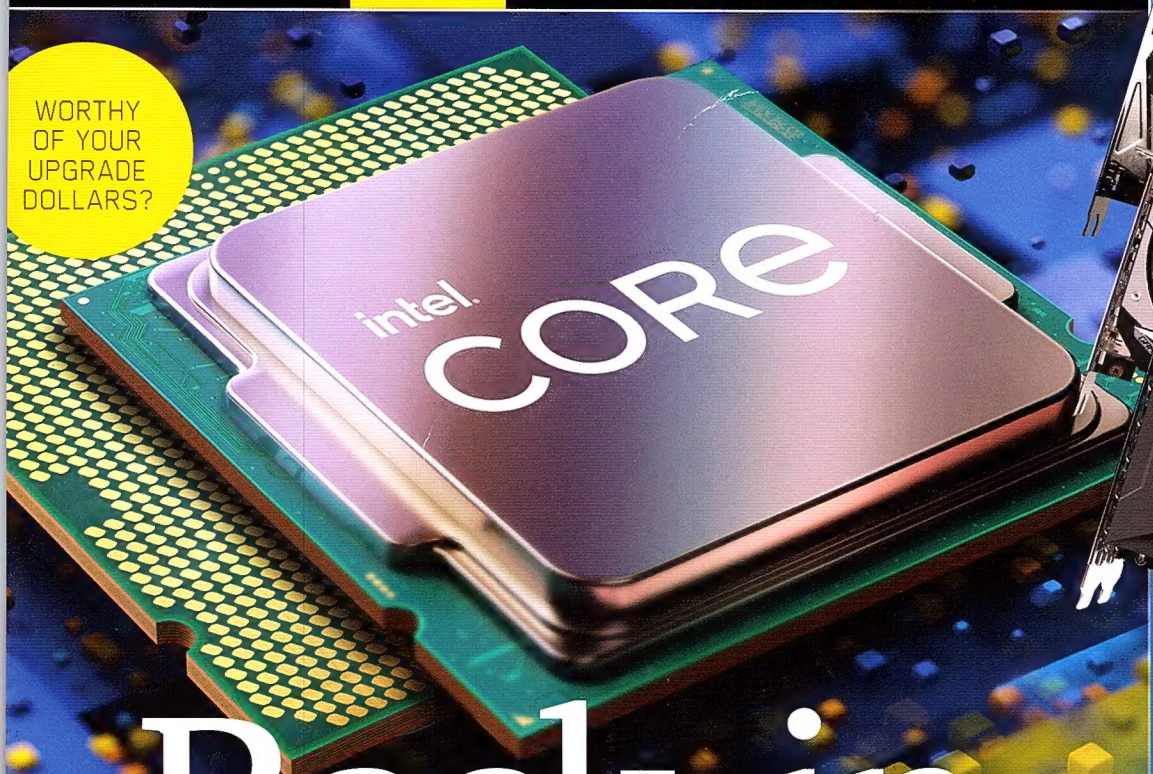
SINCE 1980

YOUR EXPERT GUIDE TO TODAY'S TECH

MAY 2021 #493

RETRO
50 YEARS OF CPUs
IN 1971 THE INTEL 4004 SET THE WORLD ON A NEW COURSE

WORTHY OF YOUR UPGRADE DOLLARS?



Back in the game?

INTEL'S HIGHLY ANTICIPATED 11TH GEN CPUs HIT THE *APC* LABS

TESTED
THE PEOPLE'S GPU
NVIDIA RTX 3060 GROUP TEST

FEATURE
UNDER THE HOOD
CODING AN OS

AV TEST: NORTON VS MCAFEE

TERRAMASTER F5-221
THE HALF PRICE NAS

NEW ASUS, ACER & LENOVO LAPTOPS TESTED

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500x VPN

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- 4 x 1G/100M/10M Ethernet Configurable WAN/LAN ports
- Multi-WAN Load Balancing & Failover
- 4 x 1G/100M/10M Ethernet LAN ports with 1 million NAT sessions
- Quad-Core CPU with 9.4 Gbps NAT throughput
- 500 x VPN tunnels including 200 x SSL-VPN tunnels
- 1 x RJ-45 console port
- 2 x USB 3.0 ports for external storage
- High-Availability (with CARP) ensuring 24/7 system uptime
- Object-oriented SPI Firewall
- Multi-subnet WAN/LAN through 802.1Q
- IPv6 & IPv4
- Bandwidth management
- Supports VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- Supports Central AP Management (up to 50 Vigor Access Points)
- Supports Central Switch Management (up to 30 Vigor Switches)
- Rack-mountable
- 2 years back to base warranty

Vigor2962 Series

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200x VPN

Multi-WAN broadband routers with 1 x 2.5GbE WAN/LAN port, 1 x 1GbE combo SFP+/Ethernet WAN/LAN port, 2 x GbE WAN/LAN ports, 2 x fixed GbE LAN ports, SPI Firewall, and 200 x VPN tunnels including 50 x SSL-VPN tunnels

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- 1 x 2.5GbE configurable LAN/WAN port *
- 1 x 1GbE combo SFP+ Fibre / Ethernet configurable WAN/LAN port
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- IPv6 & IPv4
- High-Availability (with CARP) ensuring 24/7 system uptime
- Bandwidth management
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- Central VPN Management
- Central AP Management for up to 50 Vigor Access Points
- Central Switch Management for up to 30 VigorSwitches
- Rack-mountable
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EDITORIAL

WELCOME TO ANOTHER ISSUE OF APC

EDITORIAL

Upgrade time

Things we need, and things we don't.

As Chris explains in his Two Bits column on page 18 of this issue, we're switching out the main testbed PC used in the *APC* Labs from Intel to AMD. The main reason is to take advantage of the PCIe 4 support that AMD's AM4 platform offers, and has offered long enough for it to be mature, stable and reliable. Intel will surely get there in time too, but with an increasing number of PCIe 4 SSDs being released it's important we have a platform we can trust for those reviews.

We change the testbed platform once a year or so. Unlike my main gaming / desktop rig at home, which hasn't been upgraded since late 2017 when I built it around an Intel i7 8700K. It's starting to show its age a bit in some games I like, and while it truly has years of use left in it, I want more performance, so I'm switching to an AMD Ryzen 5950X build. Outside the *APC* Labs, I don't have a lot of hands-on time tinkering with the AM4 platform and its BIOS, so I'm really looking forward to getting into it and really learning its its quirks and features.

"A simple little upgrade can often be a big deal, and sometimes it's just nice to get something new."

I actually run two gaming rigs; my big spare time hobby is sim racing and I have a pretty nice triple-screen setup with an unnecessarily fancy cockpit to sit in. An i9 9900K powers that one, and while it's true that racing sims love a fast CPU with many cores for the physics, being a triple screen setup with a resolution of 7790x1440 (bezel-corrected), it's the video card that's bottlenecking things. There's a 2080Ti in there handling that workload, and despite the big res plus game detail set quite high, it's absolutely adequate, giving me frames in the 70-80 range for most of the sims I play. G-Sync takes care of making it all buttery smooth, so that Ben PC won't need upgrading for a while.

Unless you count the sim rig upgrade that did truly excite me recently. A couple of months ago I added the Asus ROG Bezel Free Kit, and boy oh boy is it magical. I wrote a few words about it in Gadgets this month, on page 24 of this issue. It's just two clear strips of plastic, really, and while I'm excited to be enjoying the power of all 19.2 billion transistors inside the new desktop Ryzen PC, the simple bezel kit makes me smile every time I climb in for another race. The bezels are gone now. Damn things. A simple little upgrade can often be a big deal, and sometimes it's just nice to get something new.

BEN MANSILL

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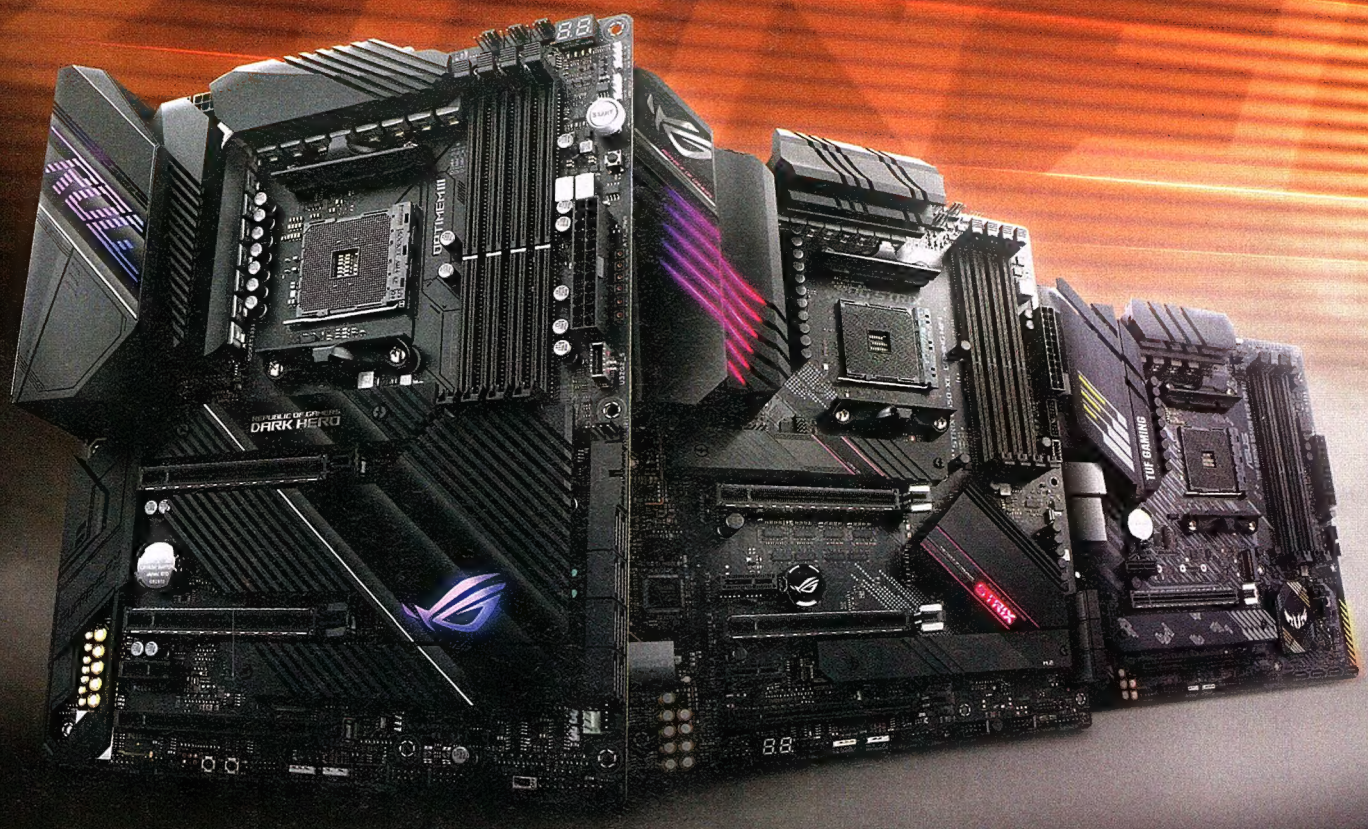

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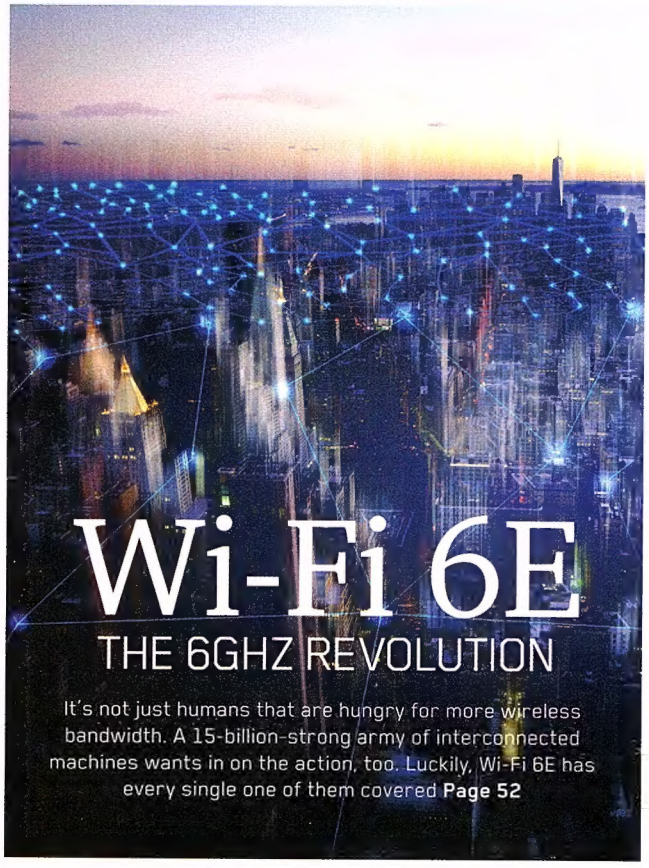
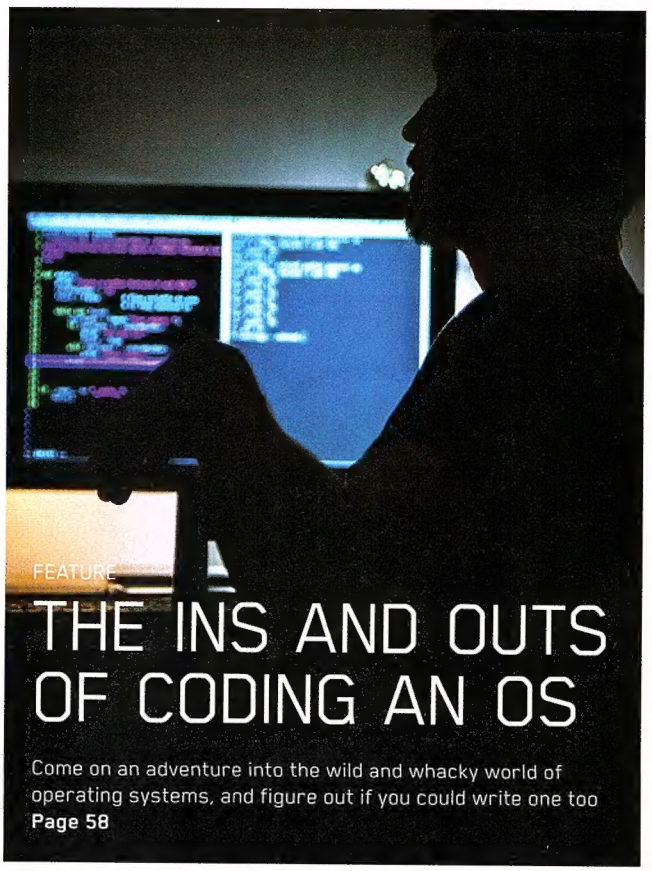


Wi-Fi 6E

THE 6GHZ REVOLUTION

It's not just humans that are hungry for more wireless bandwidth. A 15-billion-strong army of interconnected machines wants in on the action, too. Luckily, Wi-Fi 6E has every single one of them covered **Page 52**



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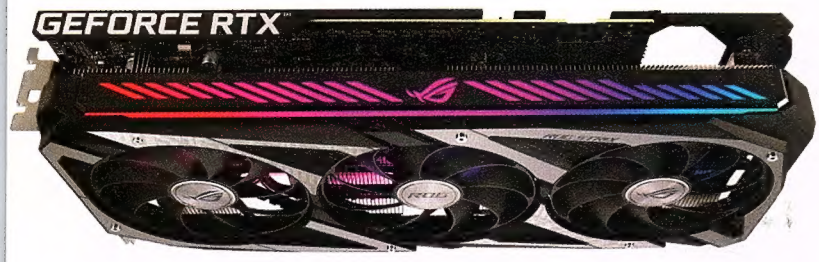

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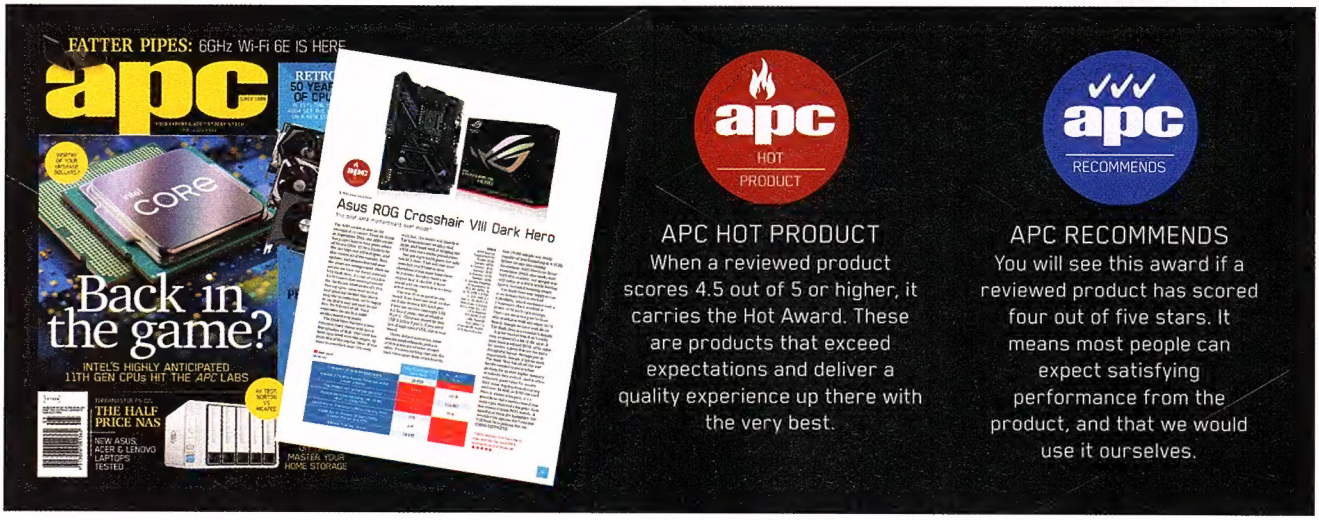
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You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

Inside *APC*

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

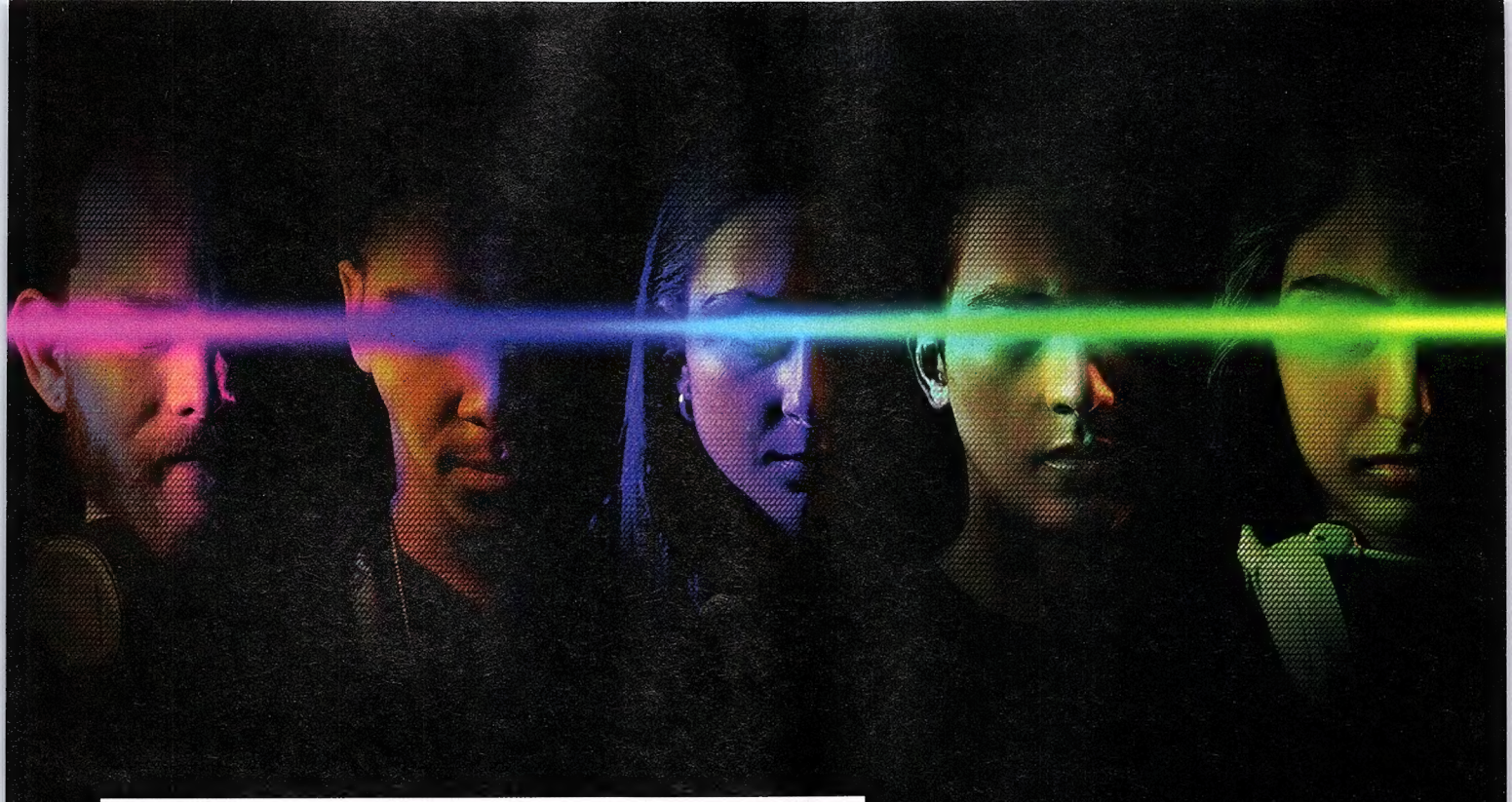
In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred. ■

APC testbed

The current *APC* testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	MSI GeForce RTX 3080 Gaming X Trio
Memory	2x8GB Team T-Force Xtreem ARGB DDR4-3600
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000



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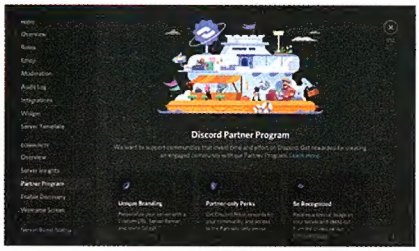

Pic: Discord

Microsoft's US$10 billion bid to buy Discord

Could happen by the end of April.

"Microsoft and Discord are in exclusive talks and could complete a deal soon, assuming the negotiations don't fall apart," the *WSJ* reports after speaking with sources familiar with the deal. There's no guarantee that Microsoft and Discord will reach an agreement soon, or indeed at all, and even if the acquisition does go through, we likely won't see any changes to Discord as a service for some time.

The acquisition could be a huge boon for the newly renamed Xbox Network, to say nothing of the Windows brand on PC, but Microsoft's plans for Discord remain to be seen. That said, you don't spend US$10 billion on a communications app to not beef up your own social network.

Pic: Quasar Zone

Crypto miners fool Nvidia's anti-mining limiter

$6 HDMI dummy plug bypassing the "unhackable".

Sometimes the toughest problems have the easiest solutions. Nvidia might claim that its hash limiter on the GeForce RTX 3060 is unhackable, but that doesn't mean that a workaround doesn't exist. Cryptocurrency miners have seemingly found the solution to the limiter, and it only costs $5.99.

Nvidia almost gave away the keys to its own kingdom when the chipmaker accidentally released a GeForce beta driver that partially disabled the limiter. The driver detects if a monitor is connected to the graphics card, but it can't tell the difference if it's a real display or not. Therefore, an HDMI dummy plug, which retails for as low as $5.99 on Amazon, easily tricks Nvidia's driver into thinking that a display is effectively present when in reality, it isn't.

Pic: Intel

CHIPS

Intel fixes 7nm, Meteor Lake and Granite Rapids coming in 2023

3D-Stacked Meteor Lake on the way to desktop PCs.

Intel's new CEO Pat Gelsinger made several big announcements about its 7nm tech at the Intel Unleashed: Engineering the Future event in late March, revealing that the company has solved the primary issues that have resulted in an untenable delay to its 7nm products. As a result, Intel will tape in its first 7nm compute chip for desktop PCs, Meteor Lake, in the second quarter of this year, with the first chips shipping to customers in 2023. Intel also divulged that it will also ship its 7nm Granite Rapids data centre CPUs in 2023.

Intel says that 7nm's issues stemmed from difficulties with series of steps in its manufacturing process and that it has leaned more heavily on EUV manufacturing to rearchitect that series of steps and simplify the design flow.

However, even though Intel has addressed the issues with its 7nm process and says that the majority of its products in 2023 will be produced in house, the delayed 7nm production schedule will leave the company in direct competition with chips built on more advanced nodes from competing foundries. As a result, Intel will also outsource the production of the CPU cores to TSMC for some of its key CPU models that will land in 2023.

Intel hasn't shared the details about its CPUs that will feature outsourced cores, but the company did share that its Meteor Lake processors are built on the 7nm process and feature the company's Foveros design. This technology allows for die-on-die logic stacking to fabricate 3D processors, as we see with Intel's Lakefield chips.

Meteor Lake chips are thought to come with a combination of Intel's Ocean Cove and Gracemont cores, meaning they'll follow the same hybrid arrangement found in Alder Lake, but in a 3D-stacked fashion. The 3D-stacked design could allow Intel to either use its own 7nm cores or swap in cores based on a process node sourced from a third-party foundry, like TSMC or Samsung, but Intel hasn't shared any details about its outsourcing strategy yet.

For the data centre products, it's hard to tell if those outsourced chips will come as chiplets or tiles that merely snap into the same Granite Rapids package, or if they will come as entirely different new models.

"Meteor Lake chips are thought to come with a combination of Intel's Ocean Cove and Gracemont cores, meaning they'll follow the same hybrid arrangement found in Alder Lake, but in a 3D-stacked fashion."

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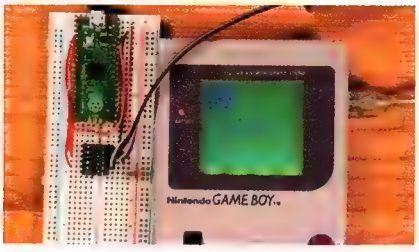
Taiwan water rationing could hurt GPU, display production

Central Taiwan ordered to cut water consumption by 15 percent.

The ongoing drought in Taiwan has already affected the production of chips such as GPUs and DRAM as well as other components in the country. Apparently, the situation is getting worse as local authorities plan to start rationing water supply starting in April. For now, the production of computer chips and displays is proceeding as usual as companies like AU Optronics and TSMC are trucking water in and drilling wells, but the situation may get worse any time now.

Production of chips and display panels requires massive amounts of pure water. Some water can be recycled, but manufacturers still require a steady water supply. SMT (surface mounted technology) electronics assembly, such as production of motherboards, graphics cards, memory modules, SSDs, and other devices featuring PCBs also requires quite a lot of water.



Pic: stacksmashing

Mine Bitcoin with Game Boy + Raspberry Pi Pico

It may take a quadrillion years, but a Game Boy can mine.

YouTuber stacksmashing has successfully repurposed his old Game Boy paired with a Raspberry Pi Pico to mine Bitcoin. Since the Game Boy lacks the required wireless connectivity, the handheld gaming console is unable to communicate with the Bitcoin network without the help of a middle man. That's why a $12 Raspberry Pi Pico is hooked into the contraption.

The Game Boy is equipped with an 8-bit Sharp LR35902 processor clocked at 4.18 MHz. The chip puts up a performance of approximately 0.8 hashes per second. For comparison, modern ASIC miners typically offer up to 100 terahashes per second. Therefore, the Game Boy is only 125 trillion times slower. Calculations reveal that it would only take a couple quadrillion years to eventually mine a single Bitcoin.

Pic: Intel

THANKS FOR THE MEMORY

Micron to sell 3D XPoint memory fab and cease further development

Wiping the memory clean.

Micron announced that it is selling its 3D XPoint fab in Lehi, Utah, bringing an end to its production of the radical new memory technology that it developed with Intel. The company plans to sell the fab by the end of 2021 and exit the 3D XPoint business entirely.

Micron will cease all further development of 3D XPoint-based products due to lacklustre demand that the company says has "insufficient market validation to justify the ongoing high levels of investments required to successfully commercialise 3D XPoint at scale." The company recently divulged that it lost US$400 million this year alone due to the lack of demand for 3D XPoint.

Intel and Micron developed the revolutionary 3D XPoint persistent memory, which melds the speed and endurance of DRAM with the persistence of data storage devices, in a secret joint effort that spanned a decade. The first formal announcement came in 2015.

Intel continues to use 3D XPoint as the underlying storage medium for its Optane products but has long relied upon Micron for its supply of 3D XPoint. The two companies have a supply agreement that lasts until the end of the year.

Intel gives glimpse of Xe-HPG DG2 gaming GPUs

Up to 512 EUs, PCIe 5.0, GDDR6.

Intel has started to publish documents related to its upcoming Discrete Graphics 2 (DG2) GPUs based on the Xe-HPG microarchitecture, inadvertently revealing some of their specifications. As expected, Intel's Xe-HPG family looks like it'll include multiple models and compete across desktops and laptops and different levels of performance.

Intel's DG2 lineup will include at least five different models for notebooks and at least two models for desktops. Notebook GPUs are referred to as SKU1 through SKU5; whereas, desktop graphics processors are SoC1 and SoC2.

The new GPUs will support a PCIe 5.0 interface, GDDR6 memory running at 14 GT/s or 16 GT/s, HDMI 2.1 and DisplayPort Alt Mode over USB Type-C, according to Intel's documents. However, it is unclear whether all the capabilities will be enabled on all SKUs. ■

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TECH BRIEF

TSMC and Samsung Foundry dominant in advanced chips

Samsung's and TSMC's cummulative CapEx spending to total $55.5 billion in 2021.

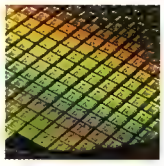
It is well known that Taiwan Semiconductor Manufacturing Co. and Samsung Foundry dominate the market of contract chip production. They are the only companies to offer leading-edge process technologies and have the largest capacities. Meanwhile, TSMC and Samsung Foundry are on track to become the dominant manufacturers of advanced chips as nobody, including Intel, can match their capital expenditures.

TSMC: big can only get bigger

Founded in 1987, TSMC was the world's first pure play foundry that manufactured chips for others. In 34 years of its history, the company has grown from a small entity with one fab to a multi-billion corporation with five 300mm fabs, seven 20mm fabs, and one 150mm production facility. Having developed dozens of process technologies throughout its history and having installed vast production capacities, TSMC can offer services to almost any fabless chip designer with almost any requirements. At present, TSMC serves over 460 customers.

As the demand for leading-edge fabrication processes and volumes from its large customers (such as Apple, HiSilicon, Qualcomm, Nvidia, and AMD) have grown in recent years, TSMC intensified building of new GigaFabs – production facilities with a capacity of more than 100,000 300-mm wafer starts per month (WSPM). Each costs around $25 billion, and TSMC also increased its research and development (R&D) budgets. The strategy has paid off and today TSMC has not only left Intel and Samsung Foundry behind with its manufacturing technologies, but it also has more leading-edge capacity than other makers of semiconductors. This is largely because because it serves virtually all fabless designers that require advanced technologies.

This year the company decided to radically increase its capital expenditure (CapEx) spending to $32 billion ~ $37 billion, an increase of 45% ~ 62% year-over-year from $22 billion in 2020. IC Insights believes that TSMC will "begin what is likely to be a huge multi-year ramp of spending," and expects the company to boost its CapEx budget in 2022 and 2023 once again.



A wafer produced by TSMC.

Being the leading maker of semiconductors both in terms of volumes and in terms of technology leadership has its advantages. First, it's easier to get the fab tools when you buy them in high volumes. Second, it's easier to set up your own production and supply chain standards, something that is tremendously important in an industry that is all about standardisation.

Samsung Foundry: closing the gap with TSMC, widening the gap with Intel?

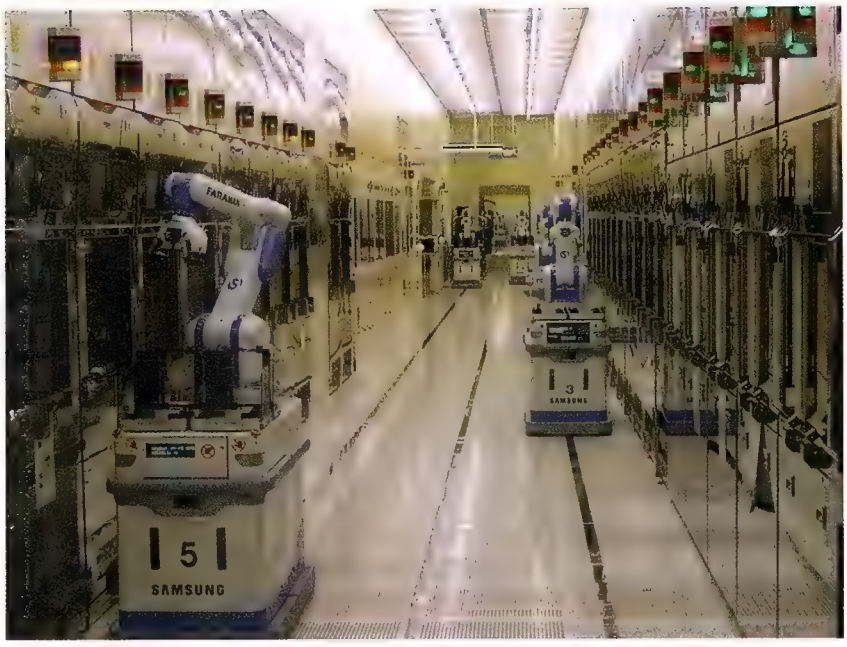
Samsung Electronics has been the world's largest maker of dynamic random access memory (DRAM) and NAND flash for quite a while and has been in the semiconductor business for decades. Furthermore, it has produced various chips for its own needs. The company started to offer foundry services in mid-2000s, as it realised that only the largest chipmakers will survive in the

long term. Samsung Foundry has been trying to catch up with TSMC for years, and while the gap is closing, it is still not quite there yet.

Samsung Foundry's largest customer is still its parent company Samsung, which strives to make the world's best smartphones, televisions, PCs, displays and other electronics. To that end, SF's design decisions at times resemble those of an integrated device manufacturer (IDM) that makes money on actual products rather than on manufacturing services.

Samsung realised early enough that demand for chips (all chips, including DRAM, 3D NAND, SoCs, etc.) will only grow, so its corporate semiconductor CapEx spending exceeded $13 billion for the first time in 2010. Having spent $120 billion on expanding production capacities over the 2017–2020 period, the company significantly closed the gap with TSMC from a capacity point of view.

Samsung Foundry is still about three times smaller than TSMC in terms of wafer starts per month (and also in terms of the number of nodes it offers), but the gap between the two has been closing. So far, Samsung has not unveiled its 2021 semiconductor CapEx budget, but analysts believe that it could spend at least as much as it spent last year – around $37 billion. Cumulative CapEx of Samsung and TSMC will total approximately $71 billion this year, according to IC Insights. A significant part Samsung's funds will of course be used to buy equipment for Samsung's memory businesses, but these two companies will be able to influence development of fab production tools and supply chains.



An area of Samsung Foundry's production line.

Inside one of TSMC's many chip fabs.

One of TSMC's offices in Taiwan.

Should Intel worry?

Intel traditionally spends tens of billions of dollars on CapEx (it spent about $18 billion last year), so it will remain a leading maker of processors. Yet, its spending on fabs will be about half that of Samsung and TSMC this year. Furthermore, since Intel will not start production of chips using a node that relies on EUV, it will not have an immediate significant influence on development of the industry and supply chains.

These days Intel's CPUs are not the undisputed leaders, and in many cases competing products from AMD are unchallenged. While Intel's 2nd generation and 3rd generation 10nm fabrication technologies are competitive against TSMC's N7, the company's nodes cannot offer the same transistor density as TSMC's N5. Finally, Intel no longer spends as much as its rivals on fabs and no longer has technological leadership.

If/when AMD becomes TSMC's second largest customer, it could ask its production partner to customise the nodes it uses in a bid to gain performance and/or lower power consumption. Meanwhile, we still know nothing about Intel's outsourcing plans other than the fact that some of its products will be made at TSMC in 2022.

Intel remains a driving force behind many industry initiatives, and no technology can get widespread in the PC world without Intel's support. Yet, there are no more Wintel-like initiatives and Intel is no longer an exclusive CPU supplier for companies like Apple.

Summary

Both TSMC and Samsung Foundry started to use EUV tools to produce chips using their leading-edge process technologies several years before Intel, so they have been gaining experience with new tools and supply chains for quite a while now.

Both TSMC and Samsung will invest two times more in their production facilities than Intel will in 2021. Arguably, Intel does not need to spend as much as TSMC and Samsung on CapEx since it only produces chips for itself, whereas its peers offer foundry services. Yet, previously Intel's technological leadership was enabled by massive spending on fabs and R&D.

In theory, governments could stimulate development of the local semiconductor industry using direct help, tax breaks, and incentives. However, their total spending over the next five years would need to exceed $195 billion, and chances of success are not high.

ANTON SHILOV ■

END USER

Instagram for Kids is a stupid idea

Social media platforms want to tap the lucrative kids market, but we shouldn't let them, writes Shaun Prescott.

If you find yourself repeatedly checking your phone throughout the day – less from need and more out of some slavish compulsion – then you'd probably quickly concede that children are better off without that habit. But tech companies are clearly eager to onboard fresh young minds onto their services, for seemingly obvious reasons. According to a March report in *Buzzfeed*, Facebook is seriously considering an Instagram for Kids, which would be targeted at users 13 and under. Currently the social media service forbids users under that age.

That report featured a leaked internal message from Instagram's vice president of product Vishal Shah. "We will be building a new youth pillar within the Community Product Group to focus on two things: (a) accelerating our integrity and privacy work to ensure the safest possible experience for teens and (b) building a version of Instagram that allows people under the age of 13 to safely use Instagram for the first time."

According to a study conducted by the Royal Society For Public Health in 2017, Instagram was the "most detrimental [social media platform] to young people's mental health and wellbeing." It beat out Snapchat, Facebook, Twitter and YouTube. Upon the study's release, RSPH chief executive Shirley Cramer wrote of Instagram and Snapchat that "both platforms are very image-focused and it appears they may be driving feelings of inadequacy and anxiety in young people."

In 2019 Instagram stopped displaying the number of 'likes' on a user's post,as well as the ability to see what images other users have liked. That was in keeping with the view that the platform had turned into a popularity contest, feeding into the "inadequacy and anxiety" of its users. As of writing it's still possible to see how many likes an image has, so long as you've got the time to count them manually.

Whatever the case, Instagram has made minor changes over the years to curb the effect of tools that can play into negative emotions. So in theory, it may be well-equipped to build a photo-driven social media platform for kids under the age of 13. Except: even if they got it miraculously right the first time, they still shouldn't.

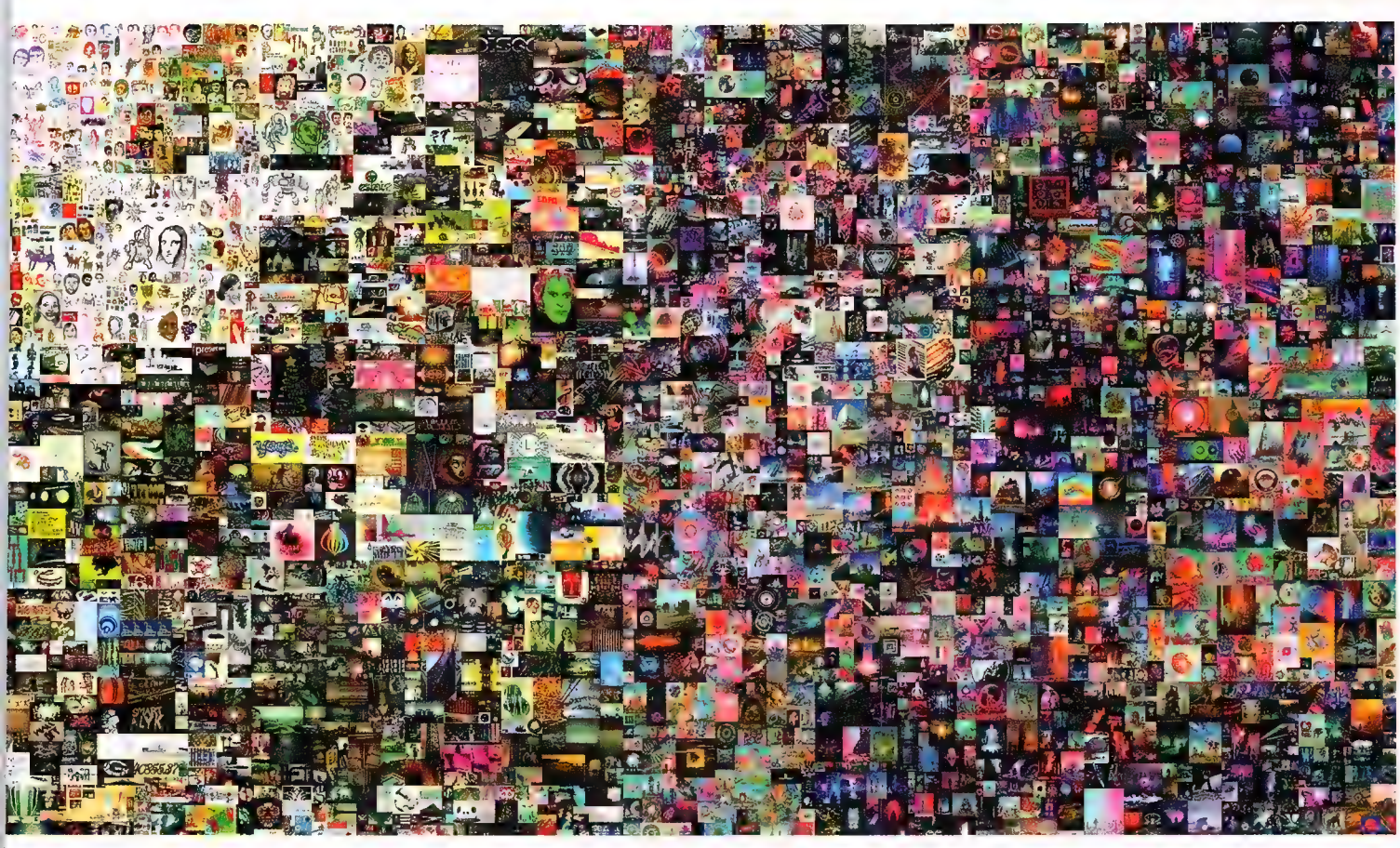
SHAUN PRESCOTT
Author, PC Gamer editor and passionate technology observer, Shaun covers trending tech topics for *APC*.

For all its many benefits, social media has undeniable negative effects on human psychology. In a 2014 Elsevier study the connections between social media usage and clinical depression were made clear. Not to mention the fact that platforms are always finding new insidious ways to keep users engaged: social media is addictive, as many studies have shown.

Basically, kids shouldn't use social media: indeed, they should be inculcated with a deep suspicion of it. Not only is it making us depressed and inadequate, but it's also driving political polarization and the general mood of aggression that seems to characterise this moment.

Of course, not everyone is going to listen to me, nor (under better advice) the various studies from better qualified folk showing the harm of social media. And if that's the case, perhaps an 'Instagram for Kids' isn't such a bad idea, because droves of parents probably let their tweens use the platform anyway. But no matter how it looks and how many promises of "privacy" and "safety" we are delivered, just remember the mess that YouTube For Kids turned into briefly in 2018. Keep your kids away from phones. ■

"Basically, kids shouldn't use social media: indeed, they should be inculcated with a deep suspicion of it."



RANDOM ACCESS

Non-Fungible-what-now?

NFT artwork sells for US$69 million and sparks new blockchain craze.

A graphic designer known for digital artworks depicting scenes like a nude Elon Musk riding the Dogecoin dog bareback, has sparked a wave of interest in NFTs and made himself one of history's highest valued artists in the process.

Six months ago not many people knew what a non-fungible token (NFT) was. Even in April the concept was only really discussed in particularly forward-thinking blockchain enthusiast forums. In March however, Mike Winkelman, the artist known by his handle Beeple, managed to sell an entirely digital NFT artwork through Christie's auction house for US$69,346,250.

The sale made Winkleman one of the top three most valuable living artists overnight, with the digital file currently valued in the top 100 most expensive artworks ever sold, just above some renowned Picasso and Van Gogh pieces.

This isn't Winkleman's first NFT artwork, on November 1st 2020, just before the national US elections on November 3rd, Beeple sold an animated GIF of a giant dead Trump corpse covered in graffiti over the Nifty NFT online art marketplace. The digital artwork managed to attract an investment of US$66,666 even though it came with the irrevocable clause: "If Trump wins, this token will change to that video of sexy boi king Trump stomping through hell FOREVER."

Unlike Banksy's self shredding 'Girl With Balloon' painting, the artist explicitly warned investors of the fluid and unknowable nature of the artwork labeling it further with "I don't want you coming back to me bitching that you spent $2M on this and now it's a video of orangeman going HAM and it's keeping u up at night popping mad boners." Since Trump didn't win in 2020, the artwork maintained its original form and changed hands again on February 25th of this year for a solid appreciation amounting to US$6.6m.

Beeple's NFTs had a lot of momentum by this point, and when you combine that with the fact that 'Everydays - The First 5000 Days' was Christie's first 'purely digital' artwork it makes sense that it achieved runaway prices.

NFT artworks use an irreplicable hashed 'proof of authenticity' code stored in the metadata that allows the image file to be exchanged and validated as a token using Ethereum smart contracts. The amazing result has sparked a broad belief that NFTs could be the answer to the exchange and commoditisation of digital artworks, but the sudden peak in interest in this novel tech means there is a tsunami of comedians and charletons minting tokens for the most ridiculous things they can think of.

Whether it's a New York director's fart audio file NFT, Jack Dorsey's US$2.9million first Tweet or the particularly Machiavellian NFT poster of the fraudulent and dangerous ponzi scheme known as Fyre Festival, sold by cleared co-conspirator Ja Rule for $122,000, there is a genuine risk of an investment bubble that threatens to undo the progress or even permanently stifle NFTs forever.

While we're pretty sure Beeple's $69m windfall means he will be able to continue his daily renditions of large Jeff Bezos cyborg heads floating over dystopian factories and giant Keanu Reeves sperm harvesting facilities, whatever the future holds, we're kind of hoping that the market wisens up to the potential for NFT scams before the bubble gets big enough to blow up any future for this valuable new blockchain tool. ■

JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

We're switching to an AMD reference system

It's been a long time!

Starting from this issue, our main reference test system has been switched to AMD! It's been a long time since AMD has held the performance crown, and though it doesn't win in every category (Intel's 10th generation CPUs remain strong at gaming), it has one key advantage that we can't ignore any longer: PCIe 4.0. This means we can now test PCIE 4.0 SSDs on the same platform without needing to switch between our 10900K and AMD Ryzen 5000 systems.

Contrary to common opinion, we reviewers aren't swimming in free hardware. The majority of it gets sent back after testing, so we must give a huge thanks to the manufacturers for their support.

Why not switch to Rocket Lake? That's simple. Our analyses rely on accurate and consistent data. While Rocket Lake offers strong performance and importantly, PCIe 4.0, it's a brand-new platform and there will be microcode and BIOS updates that will affect testing, making early data quickly obsolete. There's no way to re-test everything for every review. While we do re-test periodically if there's a new patch or Windows update or some driver wizardry, we need data to be consistent. Now that AMD's 5000 series has been out and about for many months, with X570 and the AM4 platform being well and truly mature with the kinks ironed out, it's a no brainer to select a Ryzen 5000 series system over Rocket Lake at this point in time. If Comet Lake supported PCIe 4.0, we would likely have stuck with it.

We've taken the opportunity to upgrade our test GPU from the stalwart RTX 2080 Ti to an MSI RTX 3080 Gaming X Trio. A powerful GPU is necessary to reduce GPU bottleneck. This is how we measure the gaming performance of a CPU or motherboard. If the GPU can't easily keep up, it distorts the testing. We all know a GTX 1050 will perform the same whether you use a 10100F or a 10900K, but the differences show up when you use an RTX 3080.

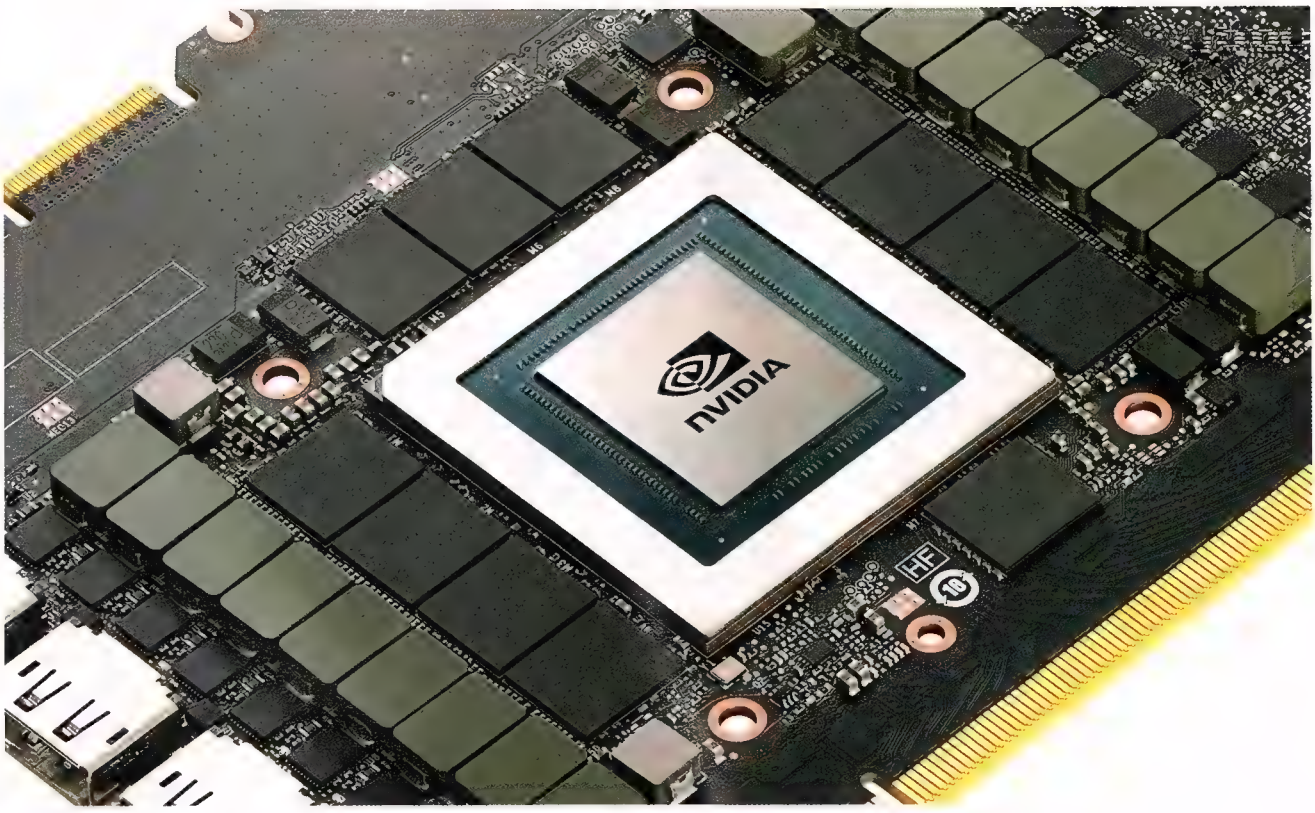
Our testing methodology remains largely unchanged. We test each benchmark three times and use the median result unless there is a major outlier or erratic results that demand investigation. Starting from this month with our RTX 3060 roundup, for GPU testing we are going to increase our emphasis on ray tracing and super resolution. It's no longer a niche tech, especially now that AMD supports ray tracing and its own DLSS competitor is coming soon. We've added *Watch Dogs: Legion* and the 3DMark Port Royal test to our GPU test suite. Both tests are easily repeatable and consistent. That's an absolute necessity for accurate analysis.

The AMD system will be in use for at least a year, if not more. If Intel 12th Generation or Ryzen 6000 CPUs really impress, we'll surely switch to one of those at some point in the future. Throw in PCIe 5.0 and DDR5 and its clear a switch will be necessary. PC tech is ever evolving. We're evolving with it. ■

CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked acoss the industry in many areas as a product and technology expert.

Our component testbed PC is intended to stay relevant for at least the next year.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	MSI GeForce RTX 3080 Gaming X Trio
Memory	2x8GB Team T-Force Xtreem ARGB DDR4-3600
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000



TECH TALK

GDDR6X hot potato

It's time to consider better memory cooling.

Graphics cards like lots of memory bandwidth. Nvidia's RTX 20-series was the first to utilise GDDR6 memory, clocked at 14Gbp – a 40 percent increase over the GDDR5X in the GTX 1080 and 1080 Ti. With the RTX 3080 and 3090, Nvidia delivered the first GDDR6X solutions, clocked at 19Gbps and 19.5Gbps, respectively. What's interesting is that, while the 3080 features chips rated for 19Gbps operation (Micron D8BGW), the 3090 chips are rated for 21Gbps (Micron D8BGX), yet they're clocked at 19.5Gbps.

It turns out that even the 19Gbps chips can get quite toasty under certain workloads, like cryptocurrency mining. At launch, there wasn't a good way to check GDDR6X temperatures on the RTX 3080 and RTX 3090, but HWiNFO64 has added a new Memory Junction Temperature as of version 6.42 that works with those GPUs. While gaming tends to max out the memory temps at 100 C or less, Ethereum mining can easily hit 110 C – the maximum allowed before the GPUs throttle and fan speeds kick up to 100 percent. Nvidia's own Founders Edition cards are particularly noteworthy for letting the memory run hot.

Micron's spec sheets for the GDDR6X chips list an operating temp of 0–95 C, but it's unclear whether that's the same as the Memory Junction Temperature reported by HWiNFO64. It's also unclear whether 100-110 C junction temps are within spec or too hot. What we do know is that the backplates on most RTX 3080 and 3090 samples can get damn hot – as in, "Ouch, I think I burned my fingers" hot.

The good news is that it's not all RTX 3080/3090 cards that have problems. Some models appear to go to huge lengths to provide better memory cooling, with EVGA's RTX 3090 FTW3 the prime example. I've tested a few 3080 cards, however, and most will break 100 C given the right (or wrong, depending on your viewpoint) workload. And the "wrong" workload in this case means Ethereum mining.

The Ethereum hashing algorithm was intentionally designed to be memory intensive,

JARRED WALTON
Jarred Walton has been a PC and gaming enthusiast for over 30 years.

and it responds well to memory overclocking. If you already know this, and if you're already running mining software, do yourself a favour and make sure you're also looking at GDDR6X temps. If you have a card where the memory hits 110 C before throttling kicks in, we're very concerned about what that will mean in the coming months of use, and would suggest looking into ways to bring that down.

Unlike memory temps, GPU thermals on the 3080 and 3090 tend to be less worrisome. Even with relatively low fan speeds, the models we've tested so far tend to stay below 70 C on the GPU. It's a shame that the memory cooling seems to have been an afterthought on many cards, including the Founders Editions. The RTX 3090 versions are particularly problematic, as they have GDDR6X on both sides of the PCB, but the rear plates don't provide active cooling on most models. If you plunk down over $2,000 for a graphics card, you'd think things like this wouldn't slip through the cracks. ■

HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND

Out comes the heat gun, which must be wielded very carefully to avoid melting all this plastic.

Apple AirPods Max

You put these on your head, we put them on the bench.

With a name like AirPods, we had to know: will the AirPods Max be serviceable to any degree? Or did Apple spend a good chunk of the $900 price on over-engineering them into knots?

MAJOR TECH SPECS

- Two 40 mm Apple-designed dynamic drivers
- Two colour-matched magnetic ear cushions
- Two Apple H1 chips
- Eight microphones for active noise cancellation
- Bluetooth 5.0 with support for the Apple-friendly AAC codec

KEY FINDINGS

- Along the bottom edge you'll find a few holes, but none are the round 3.5mm kind. Instead, wired listening is handled by the Lightning port, pulling double duty for listening and charging.
- The first step in disassembly is removing the magnetic ear cushions. Underneath the ear cushions: holes! And are those screws? We're not fighting glue yet. These are already looking like a promising departure from the rest of the AirPods we've previously scalpeled into submission. The less-than-good news is, they're Pentalobe screws. Luckily we came prepared for just about any kind of screw thanks to our Marlin screwdriver set.
- Those screws got our hopes up, but they behave strangely. They turn a little way in each direction, then stop. If you forcibly remove them like we did, you'll be rewarded with the sound of loose pieces rattling around inside the earcups – which remain sealed shut. The next round of frustration: adhesive. That's right, releasing the locks and/or removing the screws isn't enough. There's no clearance at all for prying these things out by the edges – you're going to do some damage. Since we've already removed the screws, we use a dental pick to hook under the screw holes and pull. Finally, we're in! With the screws removed, the drivers flip out, revealing a pair of repair-friendly spring contacts underneath. To our relief, both cells are fastened with screws. Even better, they provide power via a single, iPhone-style pop connector – no solder here.
- Next, the logic board. There's a unique board in each side – we extract both. Behind the two exterior slits on the lower corner of each can is a plastic air channel, which passes through to the cavity behind the driver. Presumably, this is the ventilation system that gives those drivers their distortion-free oomph at higher volumes. Hiding beneath that antenna line on the left ear cup is a big antenna. We thought this might be a counterweight, to offset the batteries in the opposite earcup – but it weighs next to nothing. The upper microphones are secured with metal brackets, screwed, and plastic-riveted into place.
- Any good headphone headband has to tilt, spin, and connect the earcups. Apple uses a wrap-around flex cable in the rotating portion of the joint, with clever routing and built-in strain relief – then switches to spring contacts for the connection to the headband. Despite the joint's complexity, you can detach the entire headband with just a SIM card removal tool or paperclip. Fully assembled, a poke in the right place compresses two tiny springs in the joint, freeing a clamp that secures the headband.
- AirPods Max Repairability Score: 6 out of 10 (10 is easiest to repair). The ear cushions attach (and detach) magnetically. The headband detaches from earcups with a poke from a paperclip or SIM card tool. Drivers and battery are secured with screws and use repair-friendly board connections. While screws are preferable to glue, the sheer number of screw types here is baffling. Pentalobe screws and adhesives guard the earcups. ■

The name "AirPods" can now refer to either tiny little in-ear headphones, or these cavernous, over-ear Max headphones

The heart and soul of the AirPods Max.

NITRO Charged for Gamers.

SAPPHIRE NITRO+ RADEON™ RX 6800 XT

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$240 | www.rog.asus.com

Asus ROG Bezel Free Kit

Cast an invisibility spell on your bezels.

If you play on a triple-screen setup, you hate bezels. This is the solution. The two plastic lens strips cover the area where the bezels meet, and using light refraction remove the bezel from visibility, leaving nothing but wraparound screen. They take but a minute to install and *APC's* sim racing editor has been road testing them and is impressed. The lenses themselves don't quite let all the light through, so you're aware of their presence, and there's a little distortion at the top and bottom of the screen where your eyes aren't level, but fine tuning the screen angles can almost eliminate that. Yes, a bit expensive for two plastic strips, but a lot of optical science and R&D has gone into these, and if you're a sim racer spending money is a way of life.

$299 | zega.com.au

Zega Digital Pot

A thermos pot that cuts the energy required for slow cooking.

Slow cooking can be one of the easiest methods for cooking meals for larger groups, but the lengthy cooking times can make it energy intensive and dangerous if left unattended. The Australian Magic Bullet blender team have developed the Zega Digital insulated smart pot to help make slow cooking easier, safer and more efficient. Using dual-wall insulation, the steel pot heats up quickly and can maintain a stable temperature for long periods, like a thermos. A Bluetooth thermometer then connects to a smartphone app and tells you when it's reached the appropriate cooking temperature so you can turn off your stove and leave it to cook till the app says it's finished.

-$650 | blog.playstation.com

PlayStation VR 2

You might have to wait till 2022.

While you might still be struggling to get a PS5, in February Sony confirmed that the next gen VR headset is being designed, but that customers shouldn't get their hopes up for a 2021 release. The company did detail the controller design for the PSVR 2 in March however, with the new controllers featuring thumb analog sticks, buttons, triggers and a frame that encircles the user's hand for better orientation detection. An LCD manufacturer co run by Sony just announced a 3.2 inch, 1,001 ppi display at 2160x2432 resolution that some experts believe will be the new PSVR display.

From $3,379 | samsung.com/au

Samsung Neo QLED TV

Has 8K finally hit the mainstream?

These Neo QLED TVs from Samsung feature mini LED backlighting that are a fortieth the size of standard LEDs allowing for a more precise backlighting array. The signal is processed by a Neo Quantum Processor that can translate video into more detailed and rich colours, even when the source is less than 8K, thanks to embedded AI processors. Smaller bezels, a suite of new sound signal processing software, and improved onboard speakers that can work with your soundbar round out an impressive feature set for a 55-inch $3,379 4K TV. Even the 65-inch 8K Neo QLED is pretty reasonable at $5,599.

$149 | store.google.com/au/

Google Nest Hub 2

A new hub to feather your nest.

Google's Nest Hub 2 isn't as exciting as some Google products we've tested, but it's still a worthy investment for anyone looking for a good value smart speaker. In addition to adding slightly bigger drivers for a 50 percent louder bass response the Nest Hub 2 introduces a set of quick gestures that allow you to interact with the device without touching it or using your voice (which is handy if you're nearby but have dirty or occupied hands). The gesture controls use an IR sensor that's also leveraged Alphabet's acquisition of Fitbit to enable sleep tracking on the device (for anyone not already using a heart rate tracker.

$750 (black), $650 (white) | oralb.com.au

Oral B IO Series 9

Cutting edge tech for your teeth.

Brushing your teeth isn't supposed to be fun. But if you're prepared to drop $700 on Oral B's computerised latest, it certainly adds a bit of pleasure to the experience. Compared to any other toothbrush you'll immediately notice how delightfully smooth it is, that's thanks to the new frictionless magnetic drive, as well as pressure sensors that reduce the speed if you're pressing too hard. It Bluetooths to an app that tracks its position in real time, telling you via a graphic of your mouth when to move on to a new area. There's an interactive gum bleeding tracker too, and it'll keep track of your brushing history and offer personal AI coaching. It's very, very nice to use, and is the highest-tech toothbrush, probably, in the world. ■

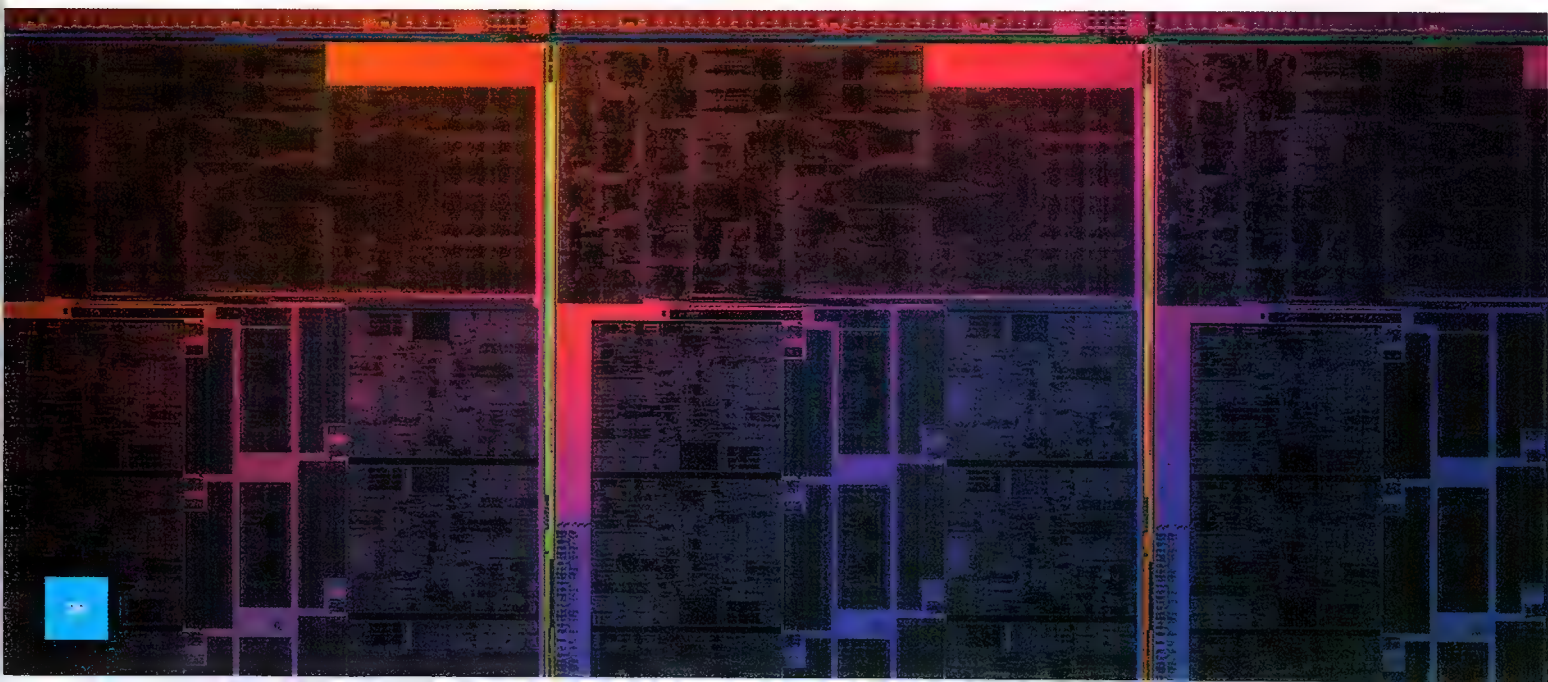
REVIEWS

THE HOTTEST GEAR LABS TESTED

Intel Core i9-11900K: $889, Intel Core i9-11600K: $419 | www.intel.com

Intel Core i9-11900K & Core i5-11600K

Is Intel back in the game?



It's hard to imagine that every generation of Intel desktop processor released since August 2015 is based on the Skylake architecture. Processors since that era, up to and including the i9-10900K all used the successful Skylake building blocks.

That makes Intel's new Rocket Lake 11th generation a hugely significant family of CPUs. It represents the company's first architectural redesign in almost six years.

Intel's struggles with 10nm manufacturing have been well documented over the last few years, yet here we are in 2021 still talking about it. At least there's light at the end of the tunnel. 10nm is ramping quickly, though it's still not ready for desktop prime time. With Skylake and 14nm having been milked for every last drop, with core counts and clock speeds maxed out, the only way to keep pace with AMD was to backport the 10nm Sunny Cove architecture to the mature (aka geriatric) 14nm process. That brings us to today. Here for review we have the highly anticipated 11th Generation Core i9-11900K and Core i5-11600K.

So what's new?

11th Generation processors feature enhanced IPC and an improved multi-core boosting algorithm. There's the long awaited PCIe 4.0 support and notably, an all-new iGPU based on the new Xe architecture. Though its usefulness is limited on the high-end models, this IGP is a very welcome upgrade for the lower tier models both for its performance improvements and upgraded video engine. Sadly, there's no HDMI 2.1 support though. Rocket Lake also introduces new hardware accelerated AI functions and AVX-512 instruction support. This means that software that supports these instructions will run much faster compared to 10th Gen CPUs. 11th Gen CPUs are compatible with Z490 motherboards after a BIOS update though PCIe 4.0 support will depend on the motherboard.

11th Gen processors bring some cool overclocking features, including the ability to change memory frequency on the fly. There's also a new memory divider, or Gear 2 which decouples the memory controller from the memory frequency. This means that memory overclocking is greatly improved. We'll go more into this in our upcoming Z590 motherboard feature.

SPECS

Intel Core i9-11900K
LGA 1200 socket; 8 cores/16 threads; 3.5GHz base clock, up to 5.3GHz boost clock; 16MB Cache; UHD 750 Graphics; Supports DDR4-3200; 125W TDP.

Intel Core i9-11600K
LGA 1200 socket; 6 cores/12 threads; 3.9GHz base clock, up to 4.9GHz boost clock; 12MB Cache; UHD 750 Graphics; Supports DDR4-3200; 125W TDP.

At the high end

The 11900K is an 8-core/16-thread CPU with a 125W TDP, though that's a meaningless number. It will suck up to 251W for short durations or even more under certain loads. As an i9 model, it features additional turbo functionality called Adaptive Boost. Essentially, the better your cooling and motherboard power delivery is, the higher the CPU can boost when using all cores, in fact, up to 5.1GHz with all cores. It sounds impressive, and in a way, it is, but there's a heavy power and temperature cost to pay. If your cooling is not top of the line, forget it.

The mid-range

The 11600K is a 6-core/12 thread model with the same 125W TDP of its bigger K brothers. It's a 6-core/12-thread model with a 3.9GHz base clock and a 4.9GHz boost clock. It's not as demanding on cooling as the 11900K and its $419 price makes it a much more compelling option under loads that don't require huge multithreading power. It's one for

"Intel's struggles with 10nm manufacturing have been well documented over the last few years, yet here we are in 2021 still talking about it."

gamers to keep an eye on.

For our testing we are running the processors according to the Intel specification, with all motherboard specific enhancements disabled. We've included an additional set of results to show the effects of Adaptive Boost which is exclusive to the i9 CPUs. Notably, Intel does not define it as overclocking. Adaptive Boost improves multi-threading performance by a lot, but as expected, it causes power consumption to skyrocket.

Performance

We were expecting more from both CPUs. They're better at gaming and single threaded performance is improved, but there's no getting around the fact that the 11900K loses two cores compared to the 10900K. Its performance is expectedly impressive under AVX loads, which is a win. The 11600K fares better compared to the 10600K but the performance alone isn't enough to see off the threat of AMD's very impressive Zen 3 CPUs.

As we indicated, the Achilles heel of 11th Gen CPUs is their heat output and power consumption. It's not shocking under a typical workload, but with Adaptive Boost enabled, the 11900K can consume well over 300W under a heavy AVX load. That's in the ballpark of 64 core Threadripper! And it also hit 100c despite using a quality 360mm AIO cooler. Thankfully, the 11600K fared a lot better with a maximum recorded peak of 189W under an all core AVX load and a peak temperature of 81c. Note that our initial testing appears to be highly variable depending on the motherboard. Some boards play fast and loose with power application, and it may be that 350W or even more is possible with an 11900K. Frankly, that's obscene.

We didn't waste our time trying to overclock the 11900K, it's already beyond the limits of our cooling. The 11600K also didn't give us a lot, with a 5.1GHz all-core overclock. We'd consider that to be adequate, but not really worth incurring a further loss of power efficiency.

One step sideways, one step back

We had high hopes for Rocket Lake, but the 14nm process and resulting inefficiency take all the shine off of it. The 11900K generally beats out the 5800X, but only with a brute force approach. It's better at multi-threading, but if you're buying it for that, you're better off with a 5900X or 10900K. We're happy to see PCIe 4.0 and the Xe integrated graphics but key new features such as AVX-512 and the AI specific instructions are of very limited value to the average desktop buyer. If you're a gamer the tradeoffs don't justify the upgrade either. Affordable 10th generation CPUs and Ryzen 5000 CPUs are simply smarter buys right now. Rocket Lake is a stop gap solution that should not exist.

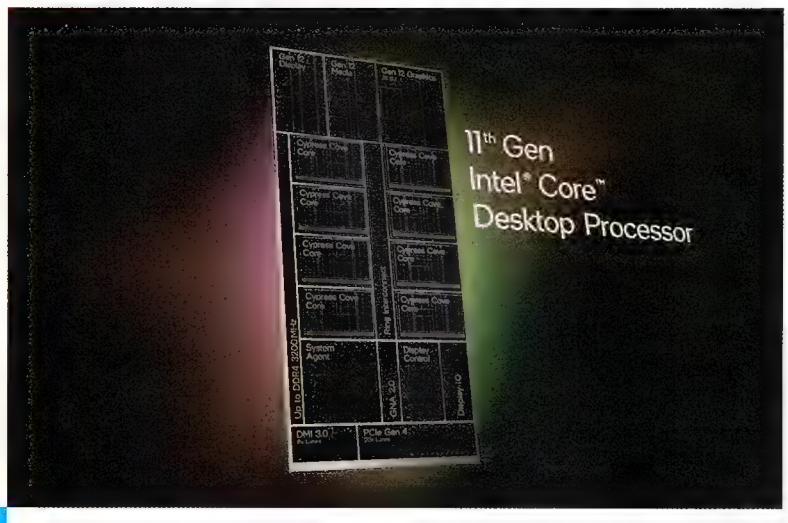
If you have the cooling to tame it, the 11900K is a very fast CPU – a very fast 8-core CPU that's expensive – that is. There's no sidestepping the fact that the 11900K is a regression in value and core count compared to the 10900K and AMD remains unchallenged with its 12- and 16-core options. The 11600K is something else. It's still a hot running CPU and it will never challenge higher core count models for multi-threaded performance, but it offers good gaming performance and value for money. It brings the improved Rocket Lake features all without the runaway power consumption. If its power efficiency could match that of AMD, we'd happily recommend it. For now, we think AMD Ryzen 5000 CPUs and Intel's own 10th generation CPUs are better buys. The 11900K retakes the gaming crown, but at what cost? Perhaps 12th generation CPUs might be the game changers we hoped 11th Gen would be.

CHRIS SZEWCZYK

The 11900K takes the gaming crown but its expense and the tradeoffs it makes in order to do it leave us unimpressed. The 10600K is a capable gaming CPU and it offers good value too.

Intel Core i9-11900K ★★★☆☆
Intel Core i5-11600K ★★★★☆

Intel finally moves away from the dated Skylake architecture, and for 11th Gen uses Sunny Cove, which was unvelied in 2018 and launched a year later in Ice Lake mobile processors.



11th Gen will be one of the last monolithic CPU designs from Intel, before it moves to the new 'Tile' design, following AMD's lead with its pioneering 'Chiplet' layout.

Intel Core i9-11900K & Core i5-11600K Benchmarks

Best result
On test

	X264 v5.0 Video Encoding	Cinebench 20	Cinebench 20	Blender 2.79 BMW Render	7Zip	POV-Ray 3.7.1
	Pass 2 Avg FPS	Multi thread Score	Single thread Score	Time (secs) Lower is better	Million Instruction per second	Ray Tracing - Pixels Per Sec
AMD Ryzen 7 5800X	53.53	6,023	622	200.4	71,002	5,565
AMD Ryzen 7 3700X	43.54	4,858	509	228.8	58,288	4,627
Intel Core i9-9900K	42.70	4,918	498	224.7	50,791	5,300
Intel Core i9-10900K	53.72	6,263	538	166.8	68,233	6,899
Intel Core i5-10600K	31.93	3,473	493	319.1	41,571	3,936
Intel Core i9-11900K (Default)	45.20	5,835	628	190.3	57,684	6,032
Intel Core i9-11900K (Adaptive Boost on)	51.20	6,289	628	180.4	59,584	6,689
Intel Core i5-11600K	35.29	4,281	594	272.9	45,739	4,588

	CPU-Z	CPU-Z	AS SSD	AS SSD	AS SSD	AS SSD
	Multi Thread Score	Single Thread Score	Sequential Read MB/s	Sequential Write MB/s	4K Read MB/s	4K Write MB/s
AMD Ryzen 7 5800X	6,720	663	5,519	3,981	84.7	207.1
AMD Ryzen 7 3700X	5,597	537	5,489	3,897	81.6	189.8
Intel Core i9-9900K	5,562	546	2,730	2,508	64.4	128.9
Intel Core i9-10900K	7,346	581	2,790	2,548	65.5	128.3
Intel Core i5-10600K	4,106	540	2807	2,560	64.5	126.4
Intel Core i9-11900K (Default)	6,649	699	5,383	3,932	81.1	194.0
Intel Core i9-11900K (Adaptive Boost on)	7,054	701	5,496	3,990	81.1	193.2
Intel Core i5-11600K	4,717	642	5,403	3,920	80.4	189.2

	Handbrake Video Encoding	Peak Power Consumption	3DMark TimeSpy	3DMark TimeSpy	3DMark TimeSpy Extreme	3DMark TimeSpy Extreme
	4K 10-Bit HEVC to 1080p FPS	POVray peak power (watts)	Overall score	CPU score	Overall score	CPU score
AMD Ryzen 7 5800X	75.8	142	16,464	11,786	8,181	5,628
AMD Ryzen 7 3700X	66.6	92	15,974	10,177	7,806	4,583
Intel Core i9-9900K	58.2	180	15,912	9,960	7,903	4,790
Intel Core i9-10900K	69.6	239	16,577	12,785	8,391	6,519
Intel Core i5-10600K	54.8	121	14965	7928	7,304	3,652
Intel Core i9-11900K (Default)	73.8	216	16309	12017	8,183	5,785
Intel Core i9-11900K (Adaptive Boost on)	76.6	307	16450	12557	8,264	6,061
Intel Core i5-11600K	60.1	189	15337	8922	7,631	4,323

	Civilization VI	Civilization VI	Civilization VI	Ghost Recon: Breakpoint	Metro: Exodus	Metro: Exodus
	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS	1080p, Ultra, DX12, AI Turn Time	1080p, Low, Avg FPS	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS
AMD Ryzen 7 5800X	236	161	7.83	189	122.7	63.7
AMD Ryzen 7 3700X	206	113	8.02	162	112.4	62.9
Intel Core i9-9900K	213	161	8.10	168	117.4	59.2
Intel Core i9-10900K	234	165	7.94	184	123.1	60.4
Intel Core i5-10600K	197	146	7.95	170	119.5	66.6
Intel Core i9-11900K (Default)	242	173	7.73	190	124.0	62.4
Intel Core i9-11900K (Adaptive Boost on)	247	175	7.72	192	124.7	62.5
Intel Core i5-11600K	217	172	7.87	179	123.7	66.9

Labs Roundup

Nvidia GeForce RTX 3060 roundup

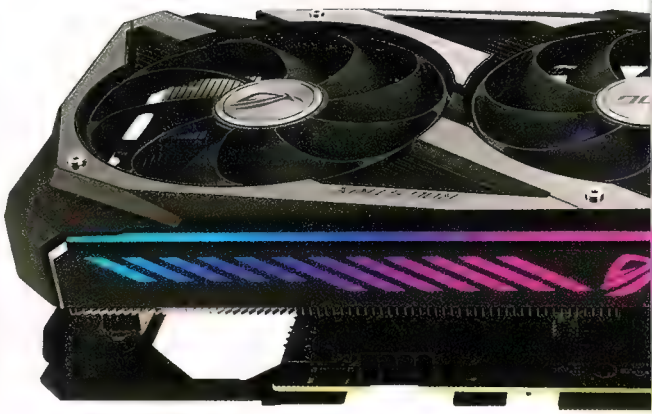
The card that mainstream gamers have been waiting for?

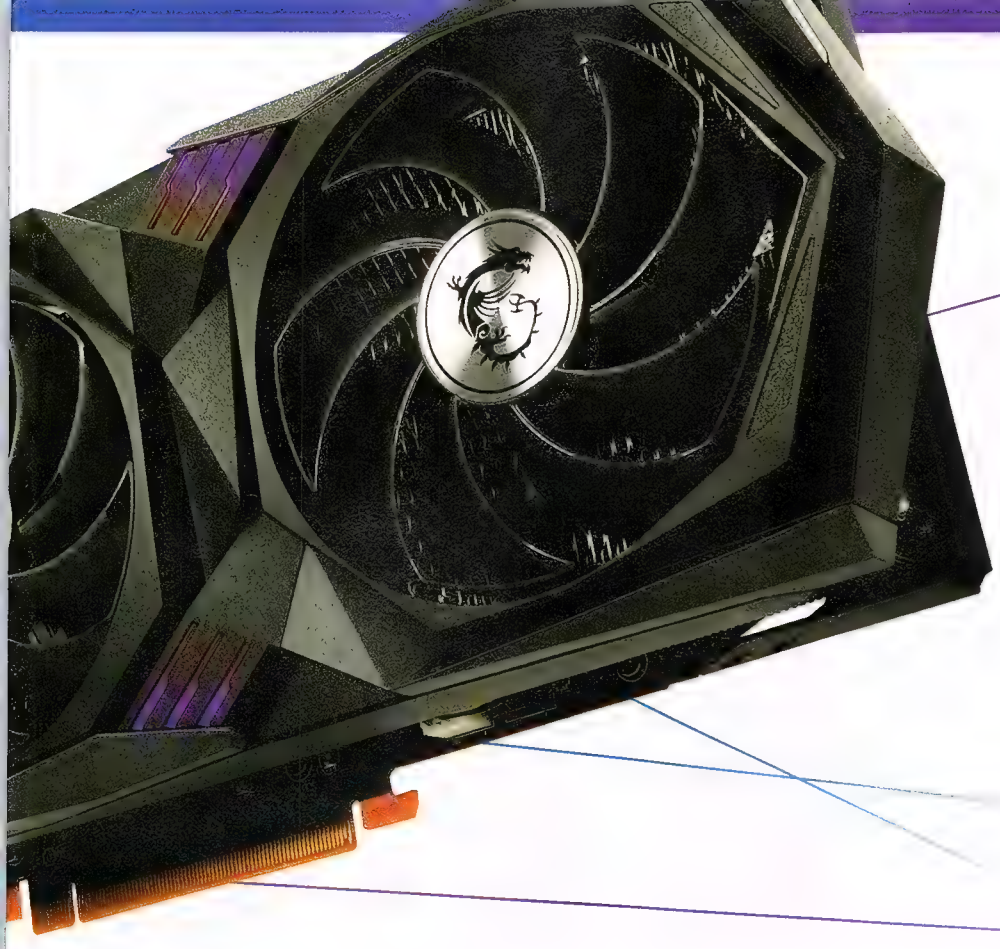
It's a really tough time to be a PC gamer. Buying any kind of current generation GPU over the last couple of months has been difficult, if not impossible at RRP. It's almost as bad on the CPU side and the wider semiconductor market beyond that. Industries that require chips for production are increasingly being bottlenecked by supply constraints. Restricted supply contributes to empty shelves, but when you combine this with unprecedented demand for GPUs, it's a real one-two punch. It comes down to crypto currency mining. The surge in value of mineable coins such as Ethereum means that miners are happy to pay massively inflated prices in the hope that they will pay for themselves, while also hoping that ETH and other coins continue to rise in value. All of this means that a card like the RTX 3060 is unlikely to be found at its recommended retail price.

As these problems are affecting the entire PC industry, we'll try not to focus too much on the market woes and instead judge the 3060 on its merits. Supply is bound to pick up in the coming months, so while price/performance will change, the fundamentals of the card will not. At least Nvidia is taking the admirable step of halving the 3060's mining performance which should make it less attractive to miners. It will be interesting to see how this plays out in the market. With that lament out of the way, let's plough ahead and look at Nvidia's mid-range hope, the GeForce RTX 3060. We've got three cards on hand to compare to one another. Do they make for a compelling upgrade? Read on and find out!

Under the hood

Any xx60 card from Nvidia is always highly anticipated. Take a look at the Steam Hardware Survey. The GTX 1060 sits at the top of the list, with cards like the RTX 2060 and GTX 1660 right up there too. While all gamers would love to be running an RTX 3090 or RX 6900 XT, not everyone is able – or perhaps more to the point – willing to shell out the very big dollars on flagship cards. It's cards like the RTX 3060 that power the lion's share of gaming PCs. Let's



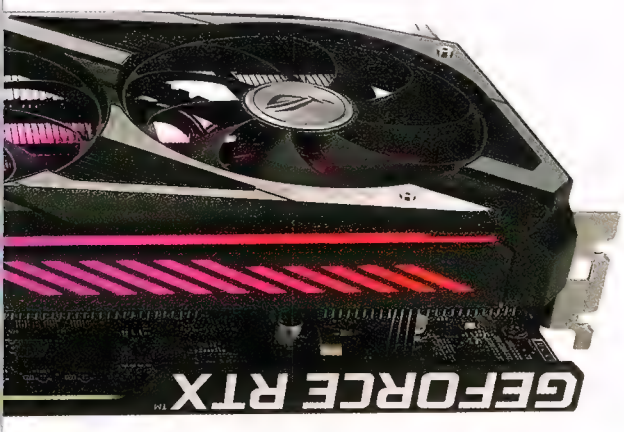


take a peek under the hood.

The RTX 3060 makes use of the smallest Ampere GPU released to date, the GA106 GPU. In packs in 3,584 Shader units along with 28 improved RT cores and 112 Tensor cores. The shader count is quite a step down from the RTX 3060 Ti which features 4,864 shaders. This, along with the Ti's 256 bit bus vs the 192 bit bus of the 3060 results in a big performance differential as you can see in the results. It makes us wonder if the 3060 could have been positioned as a 3050 Ti. The reference specification suggests a 170W TDP which is not a lot by modern enthusiast GPU standards. Even at 200W though, most 3060's can make do with a single 8-pin power connector. Nvidia recommends that the 3060 should be paired with a minimum 550W PSU. Somewhat curiously, Asus recommends a 750W PSU for its 3060 Strix.

Perhaps the most interesting feature of the 3060 is its 12GB of GDDR6 memory which is clocked at 15Gbps. 12GB might be considered overkill for this class of card, but it's always better to have too much than not enough. What it does do is make the 3060 Ti, 3070 and 3080 all look under specced.

The RTX 3060 brings PCIe 4.0 support. There's also HDMI 2.1, which is often understated in terms of its usefulness. You get 8K support of course but also things such as G-Sync Compatible support, low latency mode (ALLM), dynamic HDR and improved audio support with eARC. Big screen gaming gets a huge boost with HDMI 2.1. The 3060 should prove popular as a lounge room gaming card.



New tech time

The Ampere generation introduced a stack of new and improved technologies. These flow down and are now available to 3060 buyers. The second generation of RTX technologies are poised to take advantage of a more widely developed ecosystem that includes Direct X 12 Ultimate. Seeing ray tracing in action in a game like *Cyberpunk 2077* is a truly gorgeous sight to behold. Ray tracing is no longer a 'nice to have' feature. It's quickly becoming an accepted part of mainstream gameplay, and thankfully it's universally supported now that AMD and the consoles are slowly increasing adoption. We've added *Watch Dogs: Legion* to our test suite specifically to test RT and DLSS. We'll add to these benchmarks as time goes on. It's mainstream now.

Additional Nvidia features such as its Reflex Low latency and Broadcast technologies along with an improved video engine combine to make the RTX 3060 a compelling upgrade for users of older generation cards. That is, users with Pascal generation and older cards. Users of RTX 20 series cards will appreciate the updated features and improved RTX tech, but they won't get the generational frame rate boost that we'd hoped for. While the 3060 Ti impressively beats out all but the mighty RTX 2080 Ti, the 3060 is closer to the 2070. Perhaps we've been spoiled by the massive intergenerational performance increases we've seen with other Ampere cards. RT performance has taken a large step forward though. In the 3DMark RT feature test, the 3060 is over 20 percent faster than the 2060 Super. In truth the card lacks horsepower at higher resolutions compared to its big brothers, but at 1080p and to a lesser extent, 1440p, it's a perfectly viable and capable performer at maximum settings, with demanding titles. 120 FPS+ is a breeze with popular e-sport titles.

The RTX 3060 needs to be priced right, with stock on shelves! If it can do that, then we can pass an accurate judgement. Pricing is volatile, and that means even the most fundamental of price/performance analysis is too. It's a poor buy at $1,000, but at $600 it's something else entirely.

Yes, the market is that crazy and unpredictable! We simply don't know what the market will look like in six months. Will the mining boom pass like it did in 2018? Will supply begin to catch up to demand? Perhaps an upcoming GPU will show it a clean pair of heels? Let's toss the crystal ball aside and take a look at a selection of RTX 3060's and judge them in the here and now. Say hello to the Asus, Gigabyte and MSI GeForce RTX 3060s!

$1,059 | www.asus.com

Asus ROG Strix GeForce RTX 3060 OC

If you want a premium 3060, look no further.

You can always rely on Asus to produce a card that's worthy of being described as a flagship. The ROG Strix RTX 3060 OC has the lot. It's the fastest, the coolest, the quietest and it has the best feature set. But it carries a significant price premium. We're trying not to judge current pricing too harshly as all GPUs will certainly drop over time, but do be aware that the Asus will cost you a pretty penny. When normal times return, it will likely remain one of the most expensive RTX 3060s.

The Asus Strix is packed to the hilt with top shelf specs and features. Its boost clock is 1,912MHz in its maximum software applied OC mode, though out of the box it clocks in at 1,882Mhz, easily the highest of the roundup. There's a large RGB section across the front of the card along with an RGB ROG logo on the backplate. The backplate has a cutout to allow air to pass through. This seems to be an increasingly common design feature.

The custom PCB is powered by an eight-pin PCIe power connector. It comes with dual BIOS, which offers a performance and a quiet mode. The clock speeds are the same with both BIOS' and we could hardly hear the card under any circumstance so there appears to be little to really differentiate them. Asus includes a pair of 4-pin PWM fan headers which can react with the GPU temperature. It's a nice additional feature if you have a case with an adjacent fan or two. The 3060 Strix is one of very few modern cards to include five display outputs consisting of a pair of HDMI 2.1 ports and three DP 1.4a ports. You can only use four at a time but this kind of flexibility will be appreciated by many users.

The cooler performs exceptionally well, though we'd expect nothing less with its price premium. The highest temperature we saw was an incredible 59°C which is about as low as any card we can remember that's not entry level. This meant the card was always boosting to very high level, with a 1,960MHz average recorded after about 15 minutes of continuous running. Despite this high boost clock, the card didn't blow away the competition, with just a frame's difference here or there. More relevant is the comparison to the RTX 3060 Ti, which is much faster. This begs the question, do you want a premium 3060 that's quiet with a great feature set, or a much faster 3060 Ti that lacks a few bells and whistles and runs a bit hotter and louder? We report, you decide.

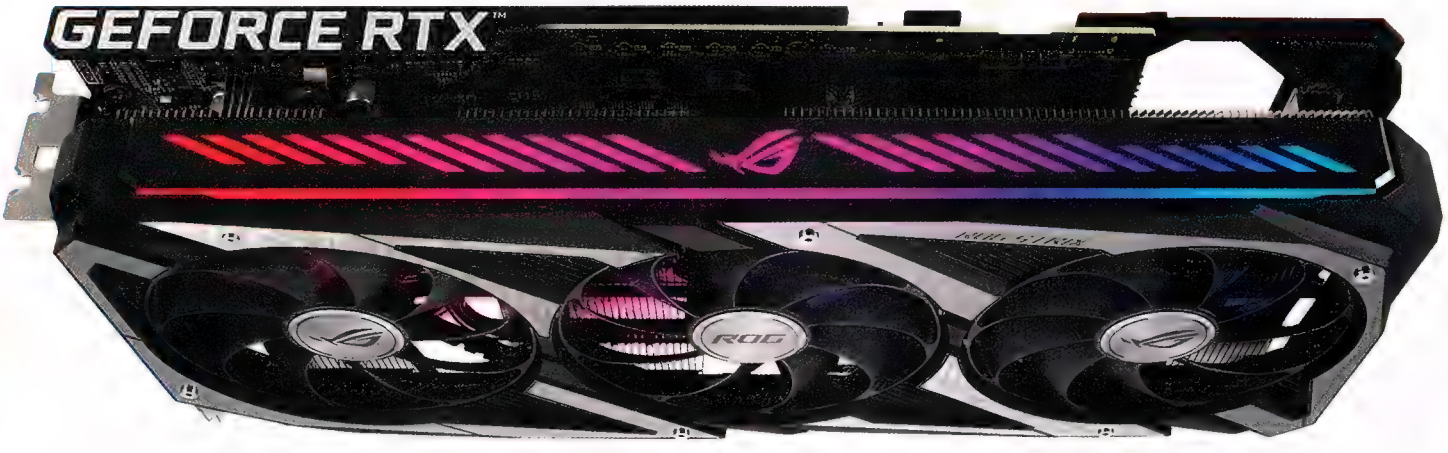
SPECS
3,584 Stream Processors, 1,320MHz Base Clock, 1,882MHz Boost Clock; 12GB GDDR6 15Gbps memory, 360GB/s Memory Bandwidth, 3x DisplayPort 1.4a, 2x HDMI 2.1, 1x 8-Pin Power Connector, 170W TDP.

This premium card has a generous serving of ports.

While the Asus Strix is easily the best card in this roundup, and perhaps of all 3060s, we question the wisdom around such a card. It's too good for its own good. To put it another way, it's a bit like powering a Corolla with a V8 engine. The monstrous Strix cooler is best suited to the likes of the 3080 or 6800 XT with their 300W+ TDPs. By all means, grab one if you want something top tier, but you'd be better off with a 3060 Ti, the cheaper MSI or one of Asus' own slightly saner RTX 3060 variants.

Asus Strix cards are always top shelf, but in this case it's complete overkill for this class of GPU.

★★★☆☆



"The Asus Strix is packed to the hilt with top shelf specs and features. Its boost clock is 1,912MHz in its maximum software applied OC mode, though out of the box it clocks in at 1,882Mhz, easily the highest of the roundup."

$829 | www.gigabyte.com

Gigabyte GeForce RTX 3060 Eagle OC

A 3060 for those on a budget.

If you're looking to upgrade but don't want to spend the bigger bucks on a premium-tier card, the Gigabyte RTX 3060 Eagle OC may be exactly what you're looking for. It's Gigabyte's entry level card. There are two models available, one with the Nvidia reference clock, and the OC model that we have on hand for this roundup which features a boost clock of 1,807MHz. This is quite a way below the Asus at 1,882MHz and the MSI 1,837MHz, but then don't forget that Gigabyte offers highly overclocked Aorus cards too.

It features a compact PCB that's surrounded by a grey shroud and backplate. The rear of the card features a large cut out to allow air to pass out the back and into the path of the airflow towards a rear mounted case fan. There is a small RGB light at the front of the card.

The Gigabyte has a couple of key characteristics that will appeal to many buyers. Firstly, it's a genuine two slot card. If you've got a small form factor system, that could be a deal maker right there. The second is the inclusion of two HDMI 2.1 ports along with two DP 1.4a ports. Although the Asus Strix has two as well, it is actually somewhat rare to find two HDMI ports on a GPU, with Gigabyte cards being the most likely to feature them. If you want to take advantage of all that HDMI 2.1 has to offer with more than one display or device, the Eagle has you covered.

SPECS
3,584 Stream Processors; 1,320MHz Base Clock, 1,807MHz Boost Clock; 12GB GDDR6 15Gbps memory, 360GB/s Memory Bandwidth, 2x DisplayPort 1.4a, 2x HDMI 2.1, 1x 8-Pin Power Connector, 180W TDP.

The 3060 Eagle's cooler can be described as adequate. It has to work surprisingly hard to keep the 170W GA106 GPU under control. During a stress test the peak recorded temperature was 69°C at a fan speed of 77 percent. Luckily the cooler makes a non-invasive kind of tone at high speed. It functions well enough but there are quieter 3060s out there, including the dual fan MSI. This also means that overclocking headroom is limited. The cooler doesn't have a lot of headroom to allow the card to boost well above 1,900MHz.

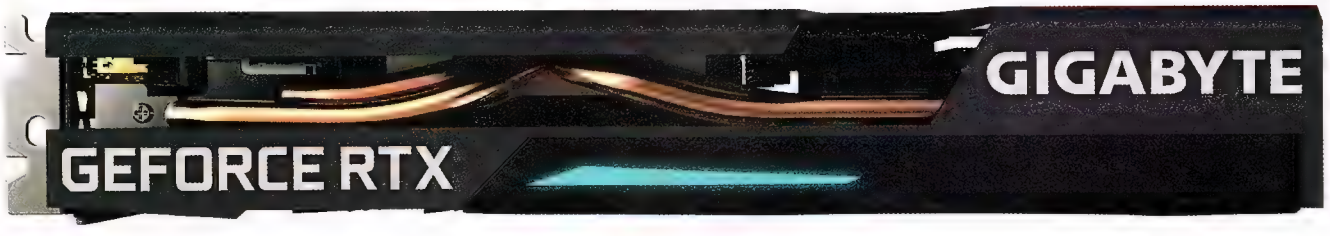
The Eagle performed surprisingly well across our benchmark suite. If your temperatures are low and there's sufficient power budget, the card will boost well above its rated clocks. The Eagle can peak over 1,900MHz at times, though it settled around 1,870 to 1,890MHz most of the time. Not bad!

The Gigabyte RTX 3060 Eagle is a good example of a minimalistic, no fuss card that's well suited to driving a 1080p screen. The 12GB of memory gives you a bit of future proofing too, particularly at 1440p where 8GB is already running into some limitations. The Eagle isn't the quietest card around but thankfully it's nothing like those annoying leaf blower reference cards.

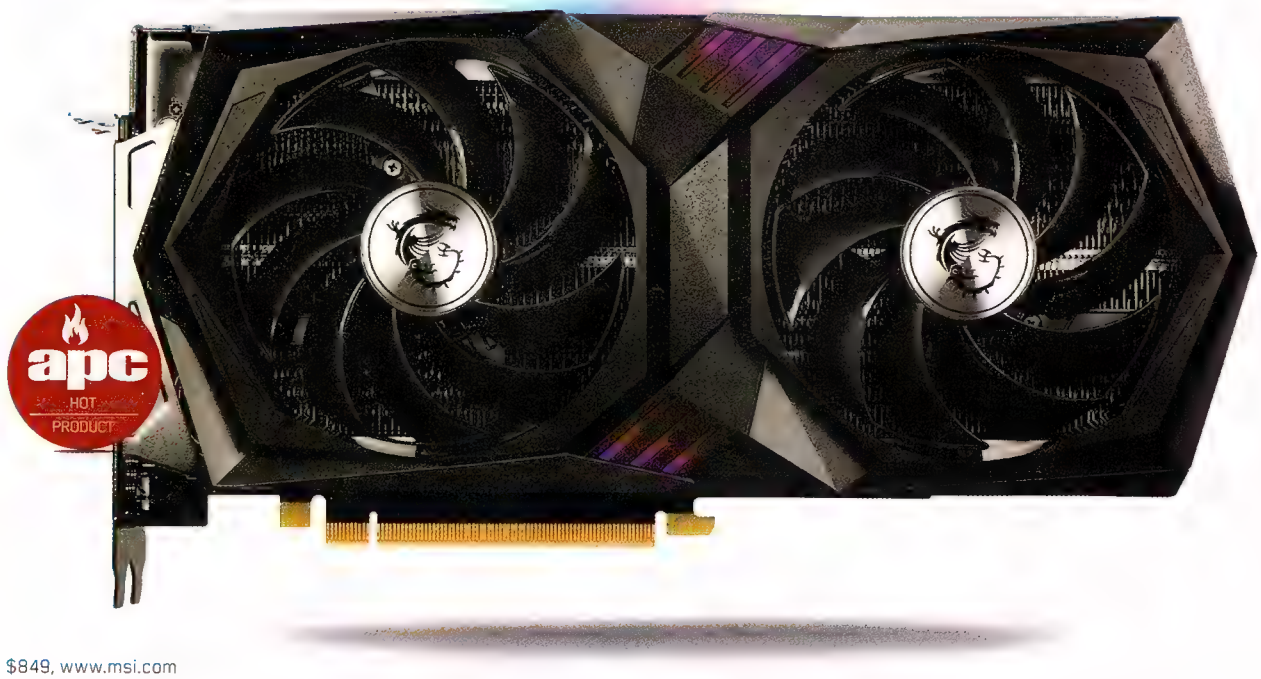
In a topsy turvy market, value carries a high weighing. At the time of writing, the Eagle OC is only a little cheaper than the MSI, which we feel is the superior card. If you're a budget conscious buyer, we'd go for the non-OC Eagle. That card happens to be one of the cheapest 3060s on the market. In a tough market where value is hard to come by, the reference clocked Eagle is the better choice.

The Gigabyte is one of the more affordable 3060s, though its cooler can't match those of the premium cards.

★★★★☆



"The MSI RTX 3060 Gaming X is a perfect example of what a mid-range card should embody. It's a step above the budget cards while keeping well below crazy 3060 ti price levels."



$849, www.msi.com

MSI GeForce RTX 3060 Gaming X

A 3060 that strikes a good balance between quality and affordability.

Sitting in between the ultra-premium Asus and the budget Gigabyte is the MSI RTX 3060 Gaming X. It's still a premium offering but it eschews some of the characteristics of the top end cards. It's aimed at buyers who scoff at the premium pricing of top tier cards but still want a quality design that's more tailored to the characteristics of the GA106 GPU.

The MSI Gaming X features a dual fan design. It sits above the mid-range Ventus and below the Gaming X Trio. It features an atypical compact PCB with a six-phase VRM, which is one phase less than the Gaming X Trio. In contrast to the high requirements of the likes of a GTX 3080 and to a lesser extent the 3060 Ti, there's simply no need for an uber overclocking capable PCB. Having said that, the Gaming X is equipped with six and eight pin power connectors, which added to the 75W available from the PCIe slot, means the Gaming X is supplied with 300W of power supply capability. You'll never need that much. The card features a factory overclock with a rated boost clock of 1,837MHz, though as is often the case with recent Nvidia GPUs, the card will boost a lot higher than this when power and temperature conditions allow it.

Other key specs include the standard 12GB of GDDR6 memory clocked at 15Gbps effective. Display outputs consist of a single HDMI 2.1 port along with three DisplayPort v1.4a ports. MSI has toned down the Gaming X's RGB implementation. There are just a couple of discrete sections on the front of the card plus the MSI logo on the side.

The MSI Gaming X is equipped with the company's latest Twin Frozr 8 dual fan cooler. It's perfectly suited to the base 170W TDP of the RTX 3060. The larger triple fan coolers are overkill. Add to that their premium pricing, and you're into 3060Ti territory. The Gaming X proves that you don't need a 3080-class cooler. We saw a load temp of just 63°C after 10 minutes at full load. This low temperature running meant the boost clock was consistently above 1,900MHz, all the while remaining effectively silent.

The MSI performs essentially the same as other 3060s.

SPECS
3584 Stream Processors; 1,320MHz Base Clock, 1,837MHz Boost Clock; 12GB GDDR6 15Gbps memory, 360GB/s Memory Bandwidth, 3x Display Port 1.4a, 1x HDMI 2.1, 1x 8-Pin & 1x 6-Pin Power Connectors, 170W TDP.

MSI's Gaming X PCB is a little more compact than most.

Though the Asus with its higher boost clock holds an edge, the real-world differences are insignificant. Despite its improved second generation RTX feature set including RT and in particular DLSS support, the 3060 doesn't raise the hairs on the back of our neck like it did when we tested the first Ampere cards. But, if you're coming from an older generation card, you'll love the upgraded performance and feature set.

The MSI RTX 3060 Gaming X is a perfect example of what a mid-range card should embody. It's a step above the budget cards while keeping well below crazy 3060 ti price levels. The Twin Frozr 8 cooling is perfect for the GA106 GPU, keeping it cool and quiet at all times which allows the card to perform above its rated boost clock. The MSI Gaming X gets it just right. It doesn't pretend to be a 3080 in disguise, and its pricing and characteristics are perfect for a mid-range card.

The MSI Gaming X strikes the perfect balance of affordability and premium features.

★★★★½

Nvidia GeForce RTX 3060 Benchmarks

Best result
On test

	Metro: Exodus						Middle Earth: Shadow of War					
	1920x1080 Ultra		2560x1440 Ultra		3840x2160 Ultra		1920x1080 Ultra		2560x1440 Ultra		3840x2160 Ultra	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	52.8	98.4	44.1	78.3	31.8	50.1	55	156	47	114	33	71
Nvidia GeForce RTX 3060 Ti	44.3	86.6	39.1	69.6	28.1	44.7	51	141	45	103	34	65
MSI GeForce RTX 3060 Gaming X	35.4	64.3	30.1	51.1	20.8	32.2	40	108	40	77	30	47
Asus ROG Strix GeForce RTX 3060 OC	35.5	64.4	30	51.3	20.8	32.5	41	110	40	78	30	48
Gigabyte GeForce RTX 3060 Eagle OC	34.1	64.3	29.8	51	20.8	32.4	40	107	39	77	26	47
Nvidia GeForce RTX 2060 Super	35.6	64.5	29.7	50.7	20.5	31.8	47	108	40	76	28	47
AMD Radeon RX 5700 XT	38.7	70.3	32.3	55.5	23.3	34.7	40	112	38	74	28	47

	Total War: Warhammer II						Temperatures C		3DMark	
	1920x1080 Ultra		2560x1440 Ultra		3840x2160 Ultra		Idle	Load	Time Spy Extreme	Port Royal
	Min	Avg	Min	Avg	Min	Avg				
Nvidia GeForce RTX 3070		114.4		83.7		50.7	32	73	6,459	8,077
Nvidia GeForce RTX 3060 Ti		105.8		78.2		46.4	39	66	5,895	7,035
MSI GeForce RTX 3060 Gaming X		84.6		58.3		34.3	38	63	4,209	4946
Asus ROG Strix GeForce RTX 3060 OC		84.8		58.5		34.8	38	59	4329	5,105
Gigabyte GeForce RTX 3060 Eagle OC		84.5		58.3		34.2	40	69	4,220	4,940
Nvidia GeForce RTX 2060 Super		78.9		57.4		34.7	37	70	4,318	5,107
AMD Radeon RX 5700 XT		82.7		55..9		32.7	37	82	4,613	N/A

	Ghost Recon: Breakpoint						Shadow of the Tomb Raider					
	1920x1080 Ultimate		2560x1440 Ultimate		3840x2160 Ultimate		1920x1080 Highest		2560x1440 Highest		3840x2160 Highest	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070	60	103	60	88	41	49	134	163	95	114	52	62
Nvidia GeForce RTX 3060 Ti	60	97	60	77	38	46	120	152	86	104	48	56
MSI GeForce RTX 3060 Gaming X	60	78	49	61	31	38	93	115	64	78	35	41
Asus ROG Strix GeForce RTX 3060 OC	60	79	49	61	31	39	94	118	67	80	36	42
Gigabyte GeForce RTX 3060 Eagle OC	60	78	49	60	31	38	93	116	64	78	35	41
Nvidia GeForce RTX 2060 Super	57	77	48	59	29	35	86	109	59	73	32	39
AMD Radeon RX 5700 XT	59	91	54	66	23	36	100	118	67	79	35	41

	Watch Dogs: Legion (RT Ultra & DLSS Balanced)						Watch Dogs: Legion (RT & DLSS Off)					
	1920x1080 Ultra		2560x1440 Ultra		3840x2160 Ultra		1920x1080 Ultra		2560x1440 Ultra		3840x2160 Ultra	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070		79		60		36		86		67		40
Nvidia GeForce RTX 3060 Ti		71		56		31		77		60		35
MSI GeForce RTX 3060 Gaming X		57		45		27		60		46		28
Asus ROG Strix GeForce RTX 3060 OC		57		45		28		60		46		28
Gigabyte GeForce RTX 3060 Eagle OC		57		44		28		59		46		27
Nvidia GeForce RTX 2060 Super		54		41		23		60		44		24
AMD Radeon RX 5700 XT	N/A	N/A	N/A	N/A	N/A	N/A		67		48		31

apc HOT PRODUCT

$2,599 | asus.com/au

Asus TUF Gaming A15

Asus is back with another AMD-powered gaming laptop, but can it really take the portable gaming performance crown three years running?

Asus's TUF Gaming A15 is back again in 2021 with 5000 series AMD CPUs and RTX 30 cards and the partnership couldn't be sweeter. AMD has been ramping up its presence in the laptop market over the last couple of years with pretty staggering performance and efficiency margins over comparable Intel products and Asus's TUF gaming laptops have been some of the first devices to showcase them.

This year the TUF Gaming A15 is fitted with an 8-core 16-thread AMD Ryzen 7 5800H CPU, 16GB of RAM and either an Nvidia RTX 3060 or 3070 GPU. The former goes for $2,099 locally while the upgraded GPU will add another $300 to that total. Both these configurations come with a 15.6-inch FullHD IPS display that runs at 144Hz, but you can upgrade the RTX 3070 configurations to a 240Hz adaptive sync screen for a total of $2,599. All of these configurations hit the sweet spot for enthusiast and competitive gamers with each offering solid value propositions.

These units are very much performance first, so they're a little thicker at 2.45cm than your average gaming ultrabook, but this extra space has been used well by the A15 keeping the internals under 92-degrees, while minimising fan noise and ensuring heat is kept away from the keyboard surround. The trackpad is very usable and even though the WASD keys are distinguished, they're marked in a subdued transparent plastic so that they're not in your face.

Because this CPU, GPU combo is so new, there's not a heap of other contemporary devices to compare it against. In general work performance it lines up pretty closely with the Intel Core i7-10870H CPU on an Aorus 15P with twice the RAM (32GB). Even with the RAM handicap the A15 wipes the floor in image rendering and media encoding tasks beating the 15P by between 13 and 45 percent. It even outpaces Intel's current Core i9-10980HK by about 25 percent, which means it's beating laptops that cost around $5-6K in processor-heavy tasks.

SPECS
Windows 10 Home 64-bit; AMD Ryzen 7 5800H CPU; Nvidia GeForce RTX 3070 GPU; 16GB RAM; 90Wh battery (8h 18min 1080p movie playback lifespan); 35.9 x 25.6 x 2.45cm; 2.3kg.

Best result

	Asus TUF Gaming A15	Aorus 15P XC
PCMark 10 - Overall (score)	6,823	6,169
Max CPU Temperature (C)	91	94
1080p movie playback (HH:MM)	08:18	04:35
HWBot x265 - 1080p (Ave fps)	55.879	49.084
3DMark Time Spy (score)	8,630	9,926
The Division 2 - 1080p Ultra (fps Av.)	99	87
CrystalDiskMark Read (MB/s)	3,567	3,267
CrystalDiskMark Write (MB/s)	2,976	2,543

Graphically this device performed roughly as you would expect, with framerates of a hundred or more on games like *The Division 2*, *F1 2020* and *Sid Meier's: Civilization VI*. This means you'll be putting those high refresh rates to good use if you dial down the settings a little or drive less graphically demanding games.

It was nice to see Ethernet and HDMI ports and while the chassis was definitely made from a lightweight plastic, it felt sturdy and had a cool overall aesthetic.

In addition to top shelf performance, battery life has been one of the main distinguishing features of the AMD laptop processor range, and the A15 doesn't disappoint in this department. Managing just shy of six hours in PCMark 10 Home Office battery benchmarks and eight hours and 18 minutes in 1080p movie playback, you should be able to get a working day's worth of battery from this gaming powerhouse, which is still rather remarkable.

JOEL BURGESS

Another amazing AMD-powered TUF gaming laptop that is well ahead in performance, price and perks.

★★★★★

$897 | lenovo.com/au

Lenovo IdeaPad Flex 5 i5 Chromebook

Lenovo's really flexing its budget Chromebooks right now.

Chromebooks are a great alternative to Windows 10 S for anyone looking to get all the functionality of a modern laptop without having to fork out thousands for a premium Ultrabook, and Lenovo seems to be dominating the space locally.

The Lenovo IdeaPad Flex i5 Chromebook is a 13.3-inch convertible laptop that uses Google Chrome OS based on Android 9. While not every app is perfectly optimised for the system – we much prefer to use the browser based Google Docs than the Chrome OS app, for example – it does at least have broad compatibility with anything you can get on the Google Play Store or as a Chrome browser extension.

The OS is built around the GSuite office apps which are a great free alternative to the pricey and less cloud focused Microsoft Office applications. And while the device only offers 128GB of onboard storage, the OS ties in nicely with Google One which costs just $2.49 per month for 100GB of cloud storage. You get a year of cloud storage for free with any Chromebook purchase that can be shared with your smartphone and accessed via any computer with an internet account.

The IdeaPad Flex i5 shares the same Intel Core i5-10210U CPU found on many 2020 Ultrabooks, which gives it more than enough power to run all the browser tabs you want. It's also got a solid 8GB RAM allocation and a reasonably speedy (863MB/s read) 128GB PCIe SSD. This spec sheet puts it on par with many Ultrabooks and it's almost identical to the Asus Chromebook Flip C436F which retails for $1,799.

Lenovo was somehow able to get the price point down to $999 (or $897 at some retailers), which puts it in direct competition with Microsoft's Surface Go 2. When you consider the IdeaPad Flex i5 Chromebook's got a larger screen and more than double the CPU processing power of a similarly priced Surface Go 2, it makes a pretty compelling argument for why you'd switch to Chrome OS.

It doesn't even have to sacrifice too much on battery life since it can manage seven hours and eight minutes in 1080p battery life tests, which is just 52 minutes less than the Surface Go 2.

The device uses an integrated Intel UHD Graphics which was designed for running games on full-fat Windows 10, so there's plenty of overhead when running the wide range of Android games available to it.

The backlit keyboard is nicely spaced and is comfortable to type on for long periods and the trackpad is also suitably smooth and easy to use. Google has done a good job of translating many of the trackpad gestures you'll get on Windows and Mac to the Chromebooks so you won't feel like you're missing out on any productivity perks.

It's also got a nice selection of interface options including two USB C, one USB Type-A, a 3.5mm headphone jack and a microSD card reader, which you can use for budget friendly storage expansion down the track, if you need it.

JOEL BURGESS

SPECS

Chrome OS 64-bit (Android 9); 13.3-inch 250nits IPS display @1920x1080 pixel resolution; Intel Core i5-10210U CPU; Intel UHD Graphics GPU; 8GB RAM; 128GB PCIe SSD; 51Wh battery (7h8min 1080p movie playback); Wi-Fi 6; Bluetooth 5; 31x21.2x1.8cm; 1.35kg.

Best result
On test

	Lenovo Ideapad Flex 5 i5 Chromebook	Lenovo Ideapad Duet Chromebook
Geekbench 5 - Single-core (score)	944	262
Geekbench 5 - Multi-core (score)	2548	932
Sling Shot (score)	4845	1,381
1080p T-Rex Offscreen (score)	3,501	2,083
Battery life - 1080p video playback (h:min)	07:08	07:45
GFX Bench Battery - Manhattan Lifespan (min)	346	331
CrystalDiskMark Read (MB/s)	3,536	3,165.8
CrystalDiskMark Write (MB/s)	2,989	3,069.1

A great cheap Windows alternative for anyone open to diving headfirst into Google's ecosystem.

★★★★★

apc RECOMMENDS

$1,098 | acer.com

Acer Swift 3x

Intel is taking on Nvidia with its own discrete Iris Xe Max mobile GPU processor, but is it just pulling a swift one on Acer's debut Ultrabook?

The headline feature of Acer's new Swift 3x is undoubtedly the fact that it features Intel's new discrete GPU – the Iris Xe Max Graphics – which can supposedly work in conjunction with the integrated GPU to deliver even better graphical performance. Intel has stressed that the discrete Xe Max Graphics was not designed for gaming, but is instead optimised for things like image rendering, AI processing and media encoding.

Despite this performance focus, there only seems to be Swift 3x configurations available with 8GB of RAM, which seems like a bit of a strange decision for a device looking to appeal to people wanting more bandwidth for creative tasks.

The Swift 3x is available exclusively through Harvey Norman as either an i7 with a 1T SSD, or a Core i5 model, with a 512GB SSD. The i5 goes for $1,199 and the i7 is usually priced at a hundred dollars more, but we saw the i7 Swift 3x on sale for just $1,098, at the time of writing. Whether it was on sale or not, the i7 is much better value than the i5 version, but if you can get it on sale the i7 is amazing value .

The 14-inch screen is 1080p and covers the full sRGB spectrum, so it's perfectly fine for this kind of device, but it's worth noting that it won't offer the vibrancy or clarity of Ultrabooks with OLED panels, HDR screens or higher resolution displays. The lack of a wider colour gamut is another perplexing omission for something pitching itself as a device for creatives.

The keyboard and trackpad don't have any obvious downfalls and while the interface options could be considered a little dated these days, with relics like a dedicated power slot, there is at least one Thunderbolt port and the HDMI cable will appeal to those who aren't already committed to the USB Type-C revolution.

Considering our reservations about the under-gunned RAM allocation, we were forced to eat our words after looking at the performance of this device, particularly in rendering and encoding. The cynic in us initially thought that Intel designed the Iris Xe Max for 'benchmark beating', but it seems to be versatile enough to mean this power is seen in real world uses.

In media encoding and image rendering the Swift 3x was between 20 percent and 86 percent better than the average of all the 11th generation Intel Evo laptops we have on file and was 17.6 percent faster than the fastest Evo device we've tested. And while it was on par with the average Evo device in lighter games, it scored up to 30 percent better framerates in more demanding games like *Metro: Exodus*, netting 43fps on Low 1080p settings.

The only real downside of the Swift 3x was battery life, which lasted only three hours and 27 minutes in PCMark 10 Home office Battery benchmarks and even less in 1080p movie playback. Clearly there's some GPU power optimisation kinks that need to be ironed out by Intel, but since it's such a new processor that'll hopefully be fixed soon through software updates.

JOEL BURGESS

An interesting new configuration for creative professionals on a tight budget.

★★★★☆

SPECS

Windows 10 Home 64-bit, 14-inch IPS display @ 1920x1080 pixel resolution; Intel Core i7-1165G7 CPU; Intel Iris Xe Max Graphics; 8GB RAM; 1TB PCIe SSD; 58Wh battery (3h7min 1080p movie playback lifespan); 31.9x20.1x1.79cm; 1.37kg.

Best result
On test

	Acer Swift 3X	Razer Book 13
PCMark 10 - Overall (score)	5,155	4,886
Cinebench R23 - CPU (multi-threaded)	6,178	4,579
Geekbench 5 - Multi-core (score)	5,291	5,427
3DMark Fire Strike (score)	6,017	4,876
Battery life - 1080p video playback (h:min)	03:07	03:41
Peak CPU temperature (°C)	96	98
CrystalDiskMark Read (MB/s)	2,232	3,536
CrystalDiskMarkWrite (MB/s)	1,972	2,989

$549 | www.terra-master.com/global

TerraMaster 5-bay F5-221 NAS

A five-bay NAS that's less-than half the price of rivals? What's the catch?

TerraMaster is a new name for *APC* but it didn't take us long to be impressed: the brushed, aluminium chassis looks classy despite it being less discreet than rivals. Physically setting it up is simple thanks to the quick-release, plastic front panels, but you'll need the included screwdriver to attach the drives to the bays.

We plugged it into our router using one of the two gigabit Ethernet ports, went to the quickstart-guide-recommended setup webpage, downloaded the TNAS discovery app, found the NAS and ran through the simple "TOS" operating system setup instructions. We tested using two, 12TB drives and were soon prompted to choose either Btrfs or Ext4 file systems before selecting a RAID array. Soon, we were looking at the TOS desktop.

The TNAS app also allows you to map a network drive to Windows. Meanwhile, a mobile version of the app enables you to browse files and backup your phone. However, mobile-based admin functions will only appear in future versions.

The device itself is not loud. There are the hard drives' clicks and pops as usual (with a slight resonance) but they're not too distracting unless under heavy load. The two fans at the rear are whisper quiet under normal operation.

The desktop will be familiar to existing NAS users: a desktop window gives you a (slightly delayed) readout for processor usage, storage and network traffic while icons provide access to settings and apps. There are many apps for many tasks in the official library including Dropbox, AWS, Alibaba and Google Cloud sync, various developer tools, backup apps, private cloud, web hosting and mail server services plus, media applications like Plex and iTunes server. Their usability will depend on what level of power user you are owing to the somewhat-underpowered specs.

Powering the NAS is a dual-core, Intel Celeron J3355 processor which operates at 2GHz with a 2.5GHz burst. There's only 2GB RAM and you can only add 4GB more – plus, you'll need to dismantle the device to install it (there are also two USB 3.0 ports and it supports up to 80TB storage). It struggled to transcode large UHD videos without horrible stuttering and you can rule out hosting any virtual machines. Having more than one person using it at once will likely cause performance issues.

SPECS
2GHz dual-core Intel Celeron CPU, 2GB DDR4 RAM (expandable to 6GB). 5x drive bays, 2 x USB 3.0, 2 x 1Gb Ethernet ports, TOS operating system.

Nonetheless, there are numerous backup features including compatibility with Windows-based Aomei Backupper backup and cloning (free version). Of particular interest is the snapshot backup technology which generates 512 snapshots for every shared folder and up to 8,192 overall system snapshots. Data recovery takes place at the file or folder level meaning it's simple to retrieve old files and file versions without doing a full system restore.

Given the choice we'd prefer Synology's superior DS1520+ but only if money were no object. The Synology costs $1,200 while the F5-221 comes in at just $549! Consequently, if your NAS requirements don't stretch far beyond shared storage, backup and modest media serving, Terra Master's F5-221 represents a welcome, affordable entry point into the world of mid-tier capacity NAS. NICK ROSS

A relatively cheap and cheerful NAS for undemanding users. But it's no professional tool.

★★★☆☆

$549 | www.dlink.com.au

D-Link Covr AX1800 three-node Wi-Fi 6 mesh system

A Wi-Fi 6 system at a reasonable price? Call us interested.

We've been somewhat unimpressed with D-Link's middling Wi-Fi offerings in recent times, but here's a three-node, Wi-Fi 6 system that costs significantly less than its rivals. Could this be the product to buy?

The three nodes are identical and quite large. They also feel a bit cheap, plasticy and lightweight but from a distance, they're relatively unobtrusive and would fit well into most stylish living rooms without blighting their appearance. Set-up is very simple: you download the app, scan a QR code in the box and follow the instructions regarding setting-up passwords. After the first node is complete, simply powering on the other two sees them added to the network automatically. You're then invited to update the firmware and are good to go in about ten minutes.

The D-Link Wi-Fi app is simple and intuitive to use but it might feel a little lightweight in features to advanced users. You can see what's connected to a network, its MAC address and IP address along with a button to block access to the network. You can also pause internet access to the entire network, connect to Google Assistant and Alexa voice controls, enable guest Wi-Fi and adjust parental controls. The latter allows you to assign different devices to different users and set bedtime or custom internet access schedules in half-hour increments. Accessing additional settings requires the old-school approach of using a web browser. This provides access to the usual consumer-based Wi-Fi features including device-priority-based QoS, port forwarding and better monitoring tools. However, it wouldn't allow us to access the network via the internet.

In terms of physical features, we were impressed to see that each node has a WPS button, a Gigabit WAN port plus four Gigabit Ethernet ports. That's very generous.

Despite the dual-band, Wi-Fi 6 AX 1800(Mbps) speed rating we've learned to take that with a pinch of salt: Wi-Fi 6 mesh systems usually lose significant velocity at distance, despite boosting coverage. We ran our usual tests in our three-storey Sydney town house which saw us downloading large video files to a Dell XPS 15 OLED laptop from a Synology DS1019+ NAS residing on the ground floor, next to the router. Up close we registered scorching 668Mbps transfer speed which is one of the top five fastest wireless speeds we've ever seen. One floor up this dropped to 158Mbps while two floors up it managed 125Mbps. Although the drop-off is significant, the transfer rates are still the best for any regular mesh on the market.

At $549 (RRP) it's significantly cheaper than its rival TP-Link Deco X60 AX3000 mesh kit which now costs $700 and is slightly slower. However, while it's nice to have a mesh system that utilises the latest Wi-Fi technology, we're still concerned about why previous-generation Wi-Fi 5 routers like D-Link's own EXO DIR-3060 are noticeably faster at distance (and cheaper at $359). Still, this is arguably the best value mesh on the market that will be able to manage multiple devices across large premises, even if speeds aren't the best at distance.

NICK ROSS

SPECS
Speed: Dual-band AX 1,800Mbps | Three nodes | Connectivity: WPS, 4x Gigabit Ethernet per node | Features: Parental controls, QoS, Port Forwarding, Google Assistant and Alexa compatible.

Potentially fast, decent coverage and a reasonable price tag – everything most people want from a mesh.

★★★★★

$549 | netgear.com

Netgear Nighthawk XR1000

Excellent wireless, but we demand more ports.

The big news with this Nighthawk model is the Wi-Fi 6 (the friendly name for 802.11ax), which tops out at a theoretical 4.8Gbps if you're using a 4x4 client card that can use the 160MHz band. That's pretty good, though in practice you'll only get near it with a very recent PCIe card. A recent MacBook Pro, iPad Pro, or PlayStation 5, or the more common 2x2 cards, can still potentially transfer data at gigabit speeds over the airwaves, though we found that it tends to go in bursts of speed and drops down to around 1Mbps in between.

Despite all this Wi-Fi tech, there's a fairly standard arrangement of ports at the back of the XR1000. Four gigabit LAN ports, one WAN connection, one USB 3.0, and the four ports for aerials join the on/off switch, power coupling, and reset button. We're starting to expect better than this – support for multi-gig fibre broadband, perhaps, with 2.5Gb LAN ports, or at least the aggregation of two Ethernet sockets into a faster one, as seen on Netgear's own RAX80. Of course, if you've got a load of modern wireless devices, you're much less likely to be using an extensive Ethernet network, but we look sadly at our networked storage with its rock-solid wired connection and lament the ways of the future.

Inside the XR1000 there's a triple-core processor with 512MB of RAM and 256MB of flash storage. It runs DumaOS 3, a rather flashy OS if you're used to the austere black-and-white functionality of other routers. Here there's colour, and charts, and add-ons called Rapps! And you have to pay $99.99 a year for security!

What's that? Yes, Netgear Armor is included with this router, but only for a month. After that you need to pay a subscription to continue with its services – which are comprehensive – or live without them. We're used to thinking of security as good and its absence as bad, but baulk at paying a subscription on top of a router that's the same price as a CPU upgrade. The presence of WPA3 means your wireless networks are secure, at least.

Everything about the XR1000 is designed to move gaming data around swiftly and wirelessly, and at this it largely succeeds, but it is always reliant on the other links in the chain performing at their best too. Putting the XR1000 at the heart of a modest home network in a suburban house, with a mixture of wired and wireless connections, we had no complaints about range or availability. Copying large amounts of data showed up a weakness in the wireless connection compared to wired, but that was in stability, not speed – exactly what we would have expected, and not something we noticed while streaming or gaming.

Sure, we'd have liked more and faster ports, but wires are not what this router is about, and it makes for a fantastic upgrade over older wireless technology. If you're equipped with the latest Wi-Fi 6 technology, then you can expect improved transfer speeds over Wi-Fi 5, the additional bandwidth helping on a congested home network too. And if low ping is important, the XR1000 has the technology to cherry-pick servers to bring it down.

IAN EVENDEN

SPECS
Wi-Fi 6, dual-band, up to 4.8Gbps; CPU: Tri-core, 1.5GHz; RAM: 512MB; Storage: 256MB; Ports: 1x WAN, 4x LAN (all gigabit) 1x USB 3.

Good wireless speeds, nice graphical OS, but restricted to gigabit Ethernet and only one USB port.

★★★★☆

apc HOT PRODUCT

$399 | www.msi.com

MSI MEG B550 Unify

A B550 board that puts many X570 boards to shame.

Depending on who you ask, the B in B550 stands for business or budget. There's nothing budget about the MSI MEG B550 Unify though. It's a premium board through and through. MSI divides its gaming motherboards into three lines, there's MAG at the lower end, MPG in the middle and MEG at the top. The MEG series includes the premium (and expensive) Godlike and Ace, so the fact that MSI includes the B550 Unify in its top product tier alongside its very best motherboards indicates we're looking at a serious piece of kit.

The B550 Unify features an all-black design, with no RGB lighting. Isn't that a surprise in these gamified times! The power delivery system wouldn't be out of place on a board that costs twice the price, with 14+2 phase PWM with 90a chokes and dual 8-pin power connectors. Do you plan to run a 5950X with ln2 cooling? Go right ahead. The heatsinks are appropriately large and chunky. Its evident when you pick up the board. It just feels solid and well built.

There no less than four M.2 slots! Though due to lane limitations you'll have to compromise elsewhere if you plan to run all four. Impressively, MSI includes comprehensive explanations and diagrams of the various combinations in the manual. Other manufacturers could learn a thing or two here.

The rear IO is well equipped but it's about par for what we'd expect. You get Realtek 2.5G LAN and Intel Wi-Fi 6 plus four USB 2.0 and four USB 3.2 Gen 2, one of which is a Type-C. There's one HDMI 2.1 port that will come into its own when Zen 3 APUs finally arrive (hurry up AMD!). The rear CMOS clear button is always welcome, as is the BIOS flashback button, which allows you to flash the board without needing to install a CPU.

AM4 boards and BIOS' are mature, though there are always ongoing BIOS updates that can affect performance. The B550 Unify performed exactly as expected, though perhaps its gaming performance was a tiny fraction behind the competing Asrock B550 Razer Edition. Not that <1% really makes any difference in a benchmark here or there.

The B550 Unify is a wonderful overclocking board. Overclocking high core count processors is mostly limited by cooling these days, but a good ability to overclock memory is a characteristic of a strong and refined motherboard. Much like the Asus Dark Hero we reviewed in this issue, the MSI Unify was able to hit an impressive 2066MHz Infinity Fabric clock which results in a memory clock of DDR4-4133 when running in the optimal 1:1 mode. If you really want, you can run much faster than this, though you'll have to drop back the Infinity Fabric a bit.

The MSI B550 Unify is a hugely impressive board. It puts many X570 boards to shame, and at $400 it's not exorbitantly priced. It will appeal to users looking for a refined and reliable overclocking focused board. Those four M.2 slots are a rarity, especially on a B550 board. In the eyes of many, they alone might make the B550 Unify the pick of all B550 boards. Perhaps it is anyway! The Unify places features, functionality and performance ahead of aesthetics and we're happy to recommend it.

CHRIS SZEWCZYK

SPECS

AM4 Socket; Supports AMD Ryzen 5000 Series/ 4000 G-Series/ 3000 Series Desktop Processors; 4x M.2; 6x SATA; Up to 5x USB 3.2 Gen 2, 2x USB 3.1 Gen 1, 8x USB 2.0; 802.11ax 2.4Gbps Wi-Fi; Realtek RTL8125 2.5G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor.

If you value overclocking performance and functionality ahead of bling, then this is the B550 board for you.

★★★★½

$799 | www.asus.com

Asus ROG Crosshair VIII Dark Hero

The best AM4 motherboard ever made?

The AM4 socket is now in the twilight of its career. Since its debut in September 2016, the AM4 socket has played host to four generations of Ryzen CPUs. X570 is likely to be the last high end AM4 chipset, and that means all of the tweaks, fixes, updates and lessons learned over the years are incorporated. Here for review we have the Asus Crosshair VIII Dark Hero. It's one of very few X570 boards that were optimised for the Ryzen 5000 series of CPUs. Having spent some time with it, and ignoring the fact that this is only the introduction, we're happy to say that it may not only be the best X570 board of all, but a contender for the best AM4 motherboard ever made.

The Dark Hero features a now common black theme with just a few splashes of RGB. The VRM has been upgraded with 90a stages, up from 60a of the regular Hero. If you want to overclock your CPU even with ln2, this board will handle it. The heatsinks are weighty and large, and work well at keeping the VRM cool even under punishment.

You get eight SATA ports but only two M.2 slots. That will suit most users but you'll have to look elsewhere if you must have three M.2 drives. Notably there's no chipset fan! A third M.2 drive would add too much heat without active cooling.

The rear IO is as good as any board. If we have one wish its that we'd like to see a 10G LAN port. There are no less than eight USB 3.2 Gen 2 ports, one of which is Type-C. These are joined by four USB 3.2 Gen 1 ports. If you need lots of high-speed USB, this is your board.

Under default operation, most similar motherboards perform within a margin of error of each other. It's overclocking that sets the Dark Hero apart from other boards.

SPECS
AM4 Socket; Supports AMD Ryzen 5000 Series/ 4000 G-Series/ 3000 Series/ 3000 G-Series/ 2000 Series/ 2000 G-Series Desktop Processors; 2x M.2; 8x SATA; Up to 5x USB 3.2 Gen 2, 10x USB 3.1 Gen 1, 4x USB 2.0; 802.11ax 2.4Gbps WiFi; Intel I211-AT 1G & Realtek RTL8125 2.5G LAN; Realtek ALC1220 7.1 Channel HD Audio; ATX Form Factor.

Best result
On test

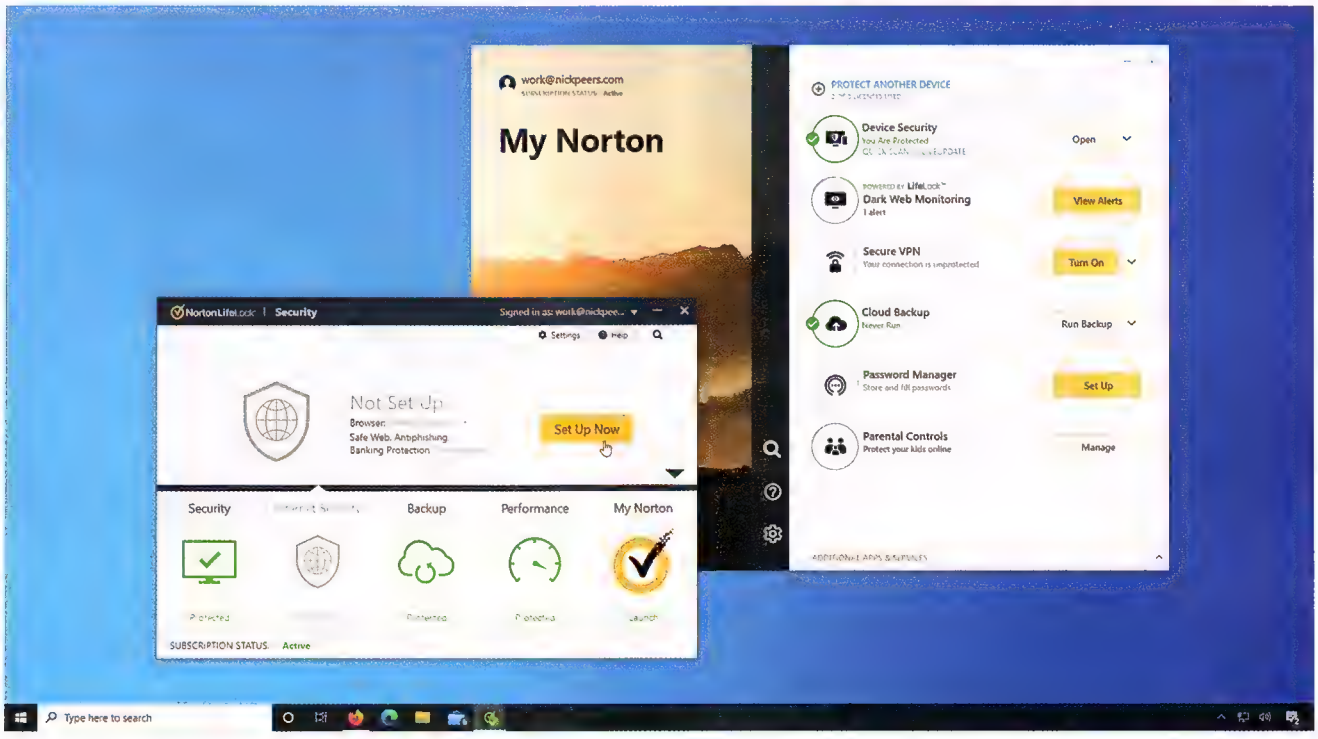
	Asus Crosshair VIII Dark Hero	Asrock X570 Taichi
Cinebench 20 Multi thread (Score)	10,033	10,072
Blender 2.79 BMW Render Time (seconds) Lower is better	117.4	117.6
7Zip (Million Instruction per second)	112,413	111,017
Handbrake Video Encoding (4K 10-Bit HEVC to 1080p FPS)	77.6	77.5
Ghost Recon: Wildlands (1080p, Low, Avg FPS)	175	176
Middle Earth: Shadow Of War (1080p, Lowest Preset, Avg FPS)	314	315
3DMark TimeSpy (Score)	14,132	14,237

Our 5950X sample was easily capable of benchmarking at 4.5GHz before we ran into cooling limitations. AMD Precision Boost Overdrive (PBO) also works well. With this enabled, our sample was still stable at 4.4GHz while leaving lightly threaded boosting intact.

The Dark Hero was happy to run at an Infinity Fabric clock of 2,066MHz, which combined with a 1:1 memory clock resulted in DDR4-4133 with tight timings. That's not something we've been able to achieve with any other X570 board, though we have with B550. The Dark Hero is a tweaker's delight.

A great motherboard isn't really easy to quantify a lot of the time. It must have a refined BIOS, offer value for money, a great feature list and a thoughtful layout. Perhaps just as importantly though, it has to work. The Dark Hero has all of this and hardly seemed to resist when pushing for an ever-higher memory or Infinity Fabric clock. And It offers relatively good value for money. With some flagship boards costing well over $1,000, at $799 the Dark Hero is almost a bargain, if it's possible to call a motherboard that costs eight hundred a bargain! Asus has released many ROG boards. A handful of them are legendary. We wouldn't bet against the Crosshair VIII Dark Hero joining that list.
CHRIS SZEWCZYK

The Crosshair VIII Dark Hero may well be the best AM4 motherboard of them all.
★★★★★



McAfee Total Protection 2021 1GHz processor, 2GB RAM, 500MB free hard drive space, Windows 10. | $231/year for 10 devices | mcafee.com
Norton 360 1GHz processor, 2GB RAM, 300MB free hard drive space, Windows 10. | $89.99/year for 3 devices | au.norton.com

Norton vs McAfee

Which of these security titans has the edge in 2021?

Once upon a time, this head-to-head would have been billed a clash of the titans. Nowadays, however, both McAfee and Norton find themselves squeezed by an increasingly crowded market. Nevertheless, both continue to hold their own, so for this match-up we've paired their premium products – McAfee Total Protection and Norton 360 Deluxe – against each other. We'll see how their core protection matches up, plus which one delivers the best range of features.

Let's begin where it matters most, with a close look at each product's ability to detect, block, and remove malware in all its forms. As always, you'll find most of what you need with the independent lab reports. Here, the omens are good for both products, with both sweeping the board with top marks from AV-TEST labs. Both also secured the highest triple-A rating from SE Labs, although McAfee came out top here on account of its perfect rating in the false-positive tests (100 percent to Norton's 96 percent). Both products achieved an "approved" certification from AV-Comparatives, but it's here you realise that while both perform superbly, they're no longer best in class (that accolade goes to either Kaspersky or Bitdefender). Only Norton passed the notoriously tricky MRG-Effitas tests with flying colours (McAfee didn't submit itself for evaluation). It translates into both products catching virtually everything the labs threw at them, including zero-day malware attacks.

When it came to system performance, McAfee proved marginally quicker than Norton in key areas, particularly when run on more powerful PCs. This saw it gain its sole award – Silver in Overall Performance – from AV-Comparatives.

Norton 360 offers powerful protection, but its UI lacks cohesiveness.

We also put both products through their paces with some real-world malware on an isolated Windows 10 VM running on macOS. Everything we tried was caught with ease, but it gave us an insight into how each product handled threats as they were detected – whether via the real-time protection component or a system scan. Here, McAfee's slick new user interface impressed us more, with its visible notifications reassuring us each time it blocked some malware in its tracks.

Ultimately, both products provide excellent core protection, while McAfee enjoys an edge in the overall performance stakes. So next we took a deep dive into the additional protections offered. Both offer a lot for your money: there's unlimited VPN as standard, along with a password manager and web plugins that scan websites as you load them for potential malicious activity. Both offer parental control tools, although McAfee's Safe Family is only offered with a 10-device

"We also put both products through their paces with some real-world malware on an isolated Windows 10 VM running on macOS. Everything we tried was caught with ease, but it gave us an insight into how each product handled threats as they were detected – whether via the real-time protection component or a system scan."

subscription. Neither holds a candle to Kaspersky's offering.

The tools then diverge. McAfee offers a handy tool for creating encrypted vaults to store sensitive files in, which enables you to store files in any cloud provider without worrying about hackers getting their hands on them. There's also a file shredder, although it's very basic.

Norton offers Cloud Backup, which lets you store personal files on the company's secure servers for both backup and security purposes. How much you get depends on your flavor of Norton 360 – a miserly 50GB with a Deluxe subscription. It's very simple to set up but doesn't make it clear how your data is encrypted, or who holds the encryption keys. Given how ubiquitous cloud storage is these days, we think McAfee's encryption option is more flexible, given you can combine it with existing cloud accounts.

However, Norton does score bonus points for its Dark Web Monitoring tool, which tracks your personal data – including email, bank account, mother's maiden name, and driver license number – and alerts you should any breaches occur. It's also added a School Time component to its parental control to help keep kids focused while learning from home.

Both apps also differ when it comes to performance optimisation options. Norton offers basic disk optimisation and file cleanup tools, along with a handy startup manager, while McAfee goes with an app booster that works proactively to hand additional system resources to apps running in the foreground. There's also the McAfee Web Boost extension, which promises to boost Google Chrome's performance by stopping videos from automatically playing.

Usability

A security product's user interface is important in guiding the user to setting both appropriate levels of protection and helping them deal with a malware attack. McAfee's 2021 product line catches the eye for all the right reasons thanks to a slick, modern new UI. Crucially, it's more than just eye candy, having been streamlined, reorganised, and made simpler to navigate. That's evident from the moment you first install the product. The app provides plenty of steering, and its alerts are large, prominent, and reassuring when they do pop up. The main window is a textbook example in restraint. All four sections– PC Security, PC Performance, My Privacy, and My Info – comprise a headline carousel of key recommendations, beneath which are a handpicked selection of icons highlighting the suite's key features.

If you're worried that McAfee is skimping on protection, click the settings button in the top right corner to reveal additional options for each component missing from the main interface, from firewall and vulnerability scanner to anti-spam tool.

At first glance, Norton 360 seems to be following similar lines, but dig deeper and you'll realise it's a clumsy amalgamation of two principal UIs. Front and center is the My Norton view, which is a slick, well-designed portal providing a quick summary of – and shortcuts to – the available protections, with a handy search tool that puts the entire suite at your fingertips.

At this point we encountered our first major irritation: despite already being activated, we were forced to log in to our Norton account again within the program to unlock several components. That's bad enough without having to jump through several CAPTCHA challenges. We then discovered our second disappointment: Norton's underlying protection still uses the "classic" interface, which is where most of your configuration time will be spent. It splits Norton 360's major components into four sections, but the somewhat dated user interface, pop-up notifications and warnings feel less intuitive and harder to navigate than McAfee's offering.

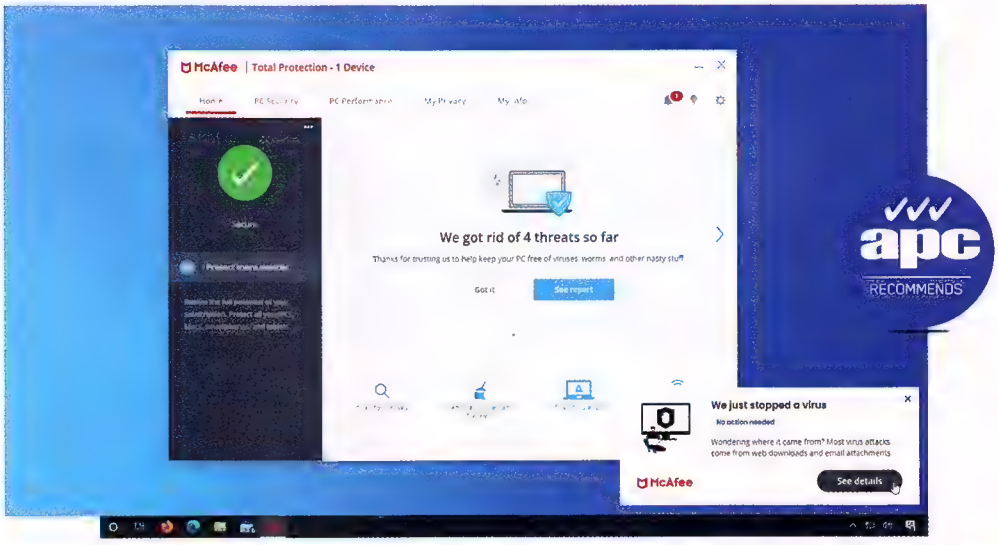
Ultimately, you'll be putting your PC's security in safe hands with either product, with Norton just edging things, but not enough in our view to sway things decisively in either app's favour (if locking down your PC as tight as possible is your sole motivation, look at Bitdefender or Kaspersky). It comes down to what additional protections you want. Norton's Dark Web Monitoring tool is a winner, but we think an encrypted file vault is more valuable than another cloud backup add-on, which tilts the pendulum back toward McAfee.

What settles things for us is McAfee's reduced demands on your system, along with its redesigned interface. McAfee Total Protection has been laid out logically to put you within easy reach of all the tools, while providing useful hints and tips. Its notifications and warnings are also more visible, which could be crucial if you find yourself under attack.

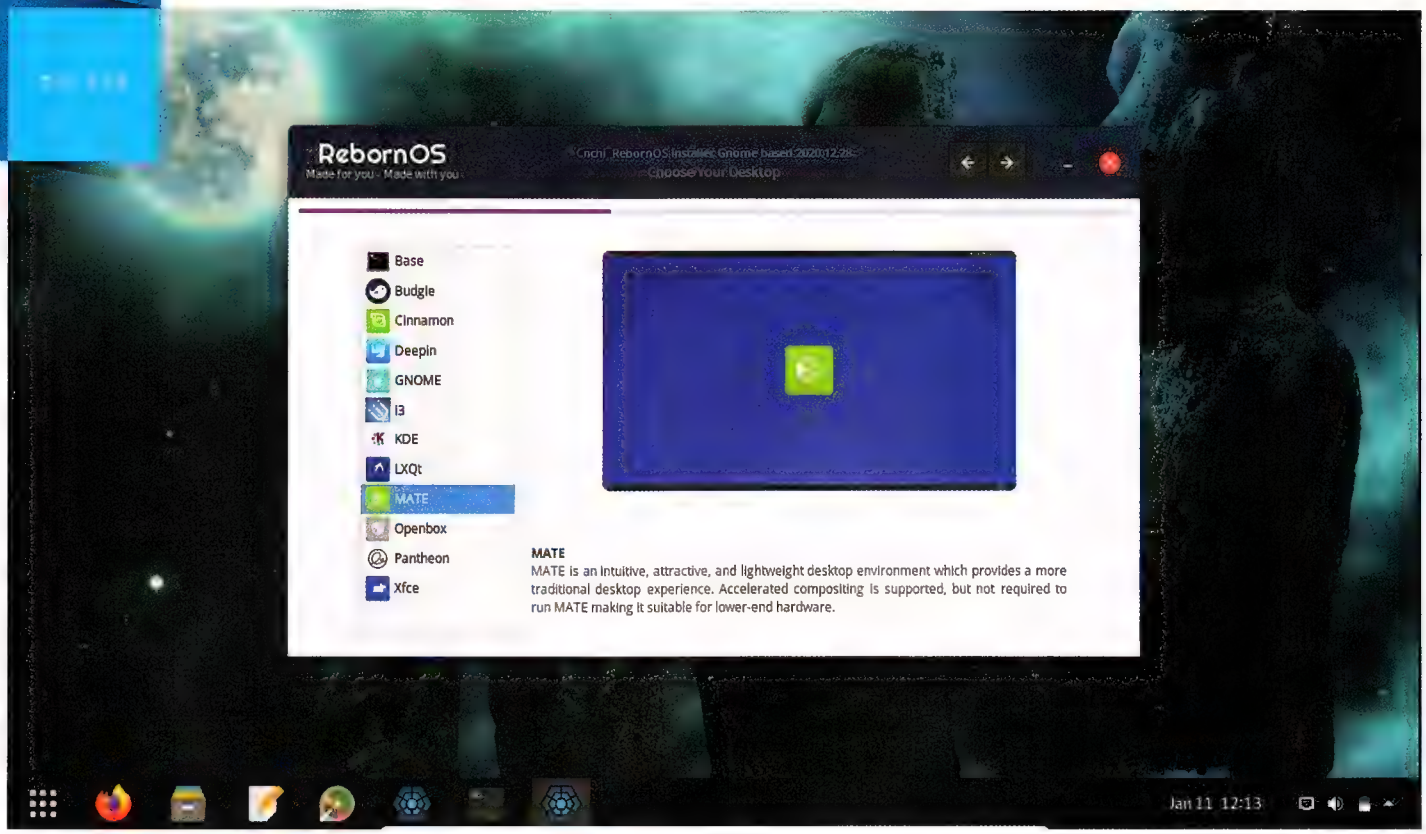
NICK PEERS

MCAFEE TOTAL PROTECTION 2021
Fast and responsive; slick but navigable UI; file encryption. Core protection not best in class; lackluster parental controls.
★★★★☆

NORTON 360
Rock-solid protection; Dark Web Monitoring add-on is good. Anti-malware components look dated; heavy touch on system.
★★★½☆


McAfee | Total Protection - 1 Device
We got rid of 4 threats so far
Got it
See report
We just stopped a virus
No action needed
Wondering where it came from? Most virus attacks come from web downloads and email attachments.
McAfee
See details
apc
RECOMMENDS

McAfee Total Protection's redesign is both attractive and practical.



Linux | rebornos.org

RebornOS 2020.12.28

The constant deluge of Arch-based distros can put anyone to sleep, but this one makes Mayank Sharma wake up from his slumber.

There are several distros that want to extend the flexibility of Arch Linux to the average desktop user without inundating them with endless options. Manjaro is our current favourite, and the now-defunct Antergos was another. In many aspects, RebornOS is the spiritual continuation of Antergos. It's put together by a team of developers that maintained the Antergos Deepin Community Edition, and builds on the unique aspects of the discontinued distro.

By its own admission, RebornOS wants to extend Arch's famed customisability to its users without forcing them to flip through manuals or drop down to the terminal. They take a swing at this lofty goal through a couple of things. The first is the custom installer based on Antergos' Cnchi. The thing about Cnchi is that unlike offline installers that dump the contents of the Live environment onto your hard disk, it's designed to fetch the latest packages from online repositories.

The RebornOS developers build on this ability and smartly tweak the installer to offer you the option to download and use from about a dozen desktop environments, including mainstream ones such as Gnome, KDE and Cinnamon, lightweight ones like Mate, Openbox, Xfce and LXQt, and aesthetically pleasing ones such as Budgie and Deepin.

In the same vein, the installer also enables you to customize the selection of programs. For instance, while the distro by default installs Firefox, you can replace or supplement it with Chrome, Opera or Vivaldi. There's a similar range of options available for office suites, namely LibreOffice, Free Office and WPS Office. You can also pull in some popular proprietary tools such as Steam, Dropbox and Spotify, and there are several other options including some for advanced users, too.

Very thoughtfully, the Cnchi installer gives you the option to create a recovery partition, which it uses as a cache for the packages you've chosen. In case the installation is interrupted for some reason, you can resume it with this recovery partition without having to download all the previously fetched packages. It's best to use a USB disk for this recovery cache.

Post installation, RebornOS feels and behaves like any other Arch-based desktop distro. There's the Pamac graphical tool, which is one of the popular front ends to Arch's pacman package management system. The distro has already enabled the option to build and install packages from the Arch User Repository (AUR) and you can also choose to enable support for installing distro-agnostic Flatpaks.

RebornOS's custom administration tool also has a front-end to the CLI wormhole utility, which can be thought of as an open source alternative to AirDrop.

MINIMUM SPECS

CPU: Any modern 64-bit CPU, Memory: 2GB, HDD: 20GB (varies based, on desktop environment), Build: Only for 64-bit machines.

The game-changing feature of the distro, however, is the recently renamed RebornOS FIRE administration utility. FIRE is an abbreviation for Features and Improvements in RebornOS made Easy, and true to its name the tool enables you to tweak several essential aspects of your installation graphically. For instance, you can customise and switch to either LightDM or SDDM as the default display manager, and also install any of the other supported desktop environments. The program also helps you perform several system tasks without firing up the terminal, such as clearing the package cache or removing orphaned packages, or reinstalling the GRUB boot loader.

You can also use FIRE to install the Anbox compatibility program for running Android apps on Linux, and also fire up several tools such as Pace, for graphically editing pacman's settings, and the Arch Kernel manager utility to install and switch to another kernel.

A refreshing take on making a desktop friendly rendition of Arch that can create customised installations, too.

★★★½☆

ANDROID (&IOS)

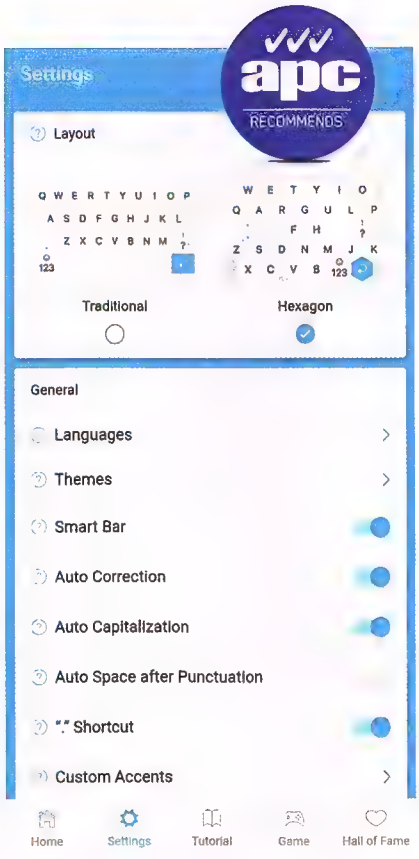
Drops Language Learning & Vocabulary App by Kahoot

Drop some knowledge.

Free/subs

There's quite a few different language learning apps around, and as Drops was in a recommended list I figured it was worth a try. It hosts a plethora of different languages to choose from, and then teaches them to you using a drag and drop method. It's very simple and nicely tactile with clear instructions. Most of the motions are larger sweeping ones rather than needing any fine controls, so it feels like an app that will be accessible to many. I also enjoy the way it breaks up languages into topics so you can specifically learn about something that might be relevant to you. I started with Japanese, and the main complaint I have is it felt like most words were loaner English, which is common but doesn't feel like you're learning all that much. I'm hoping this will improve with more learning but for now it's a relatively easy way to get some language learning into your life. HOPE CORRIGAN

★★★☆☆



Android (&iOS)

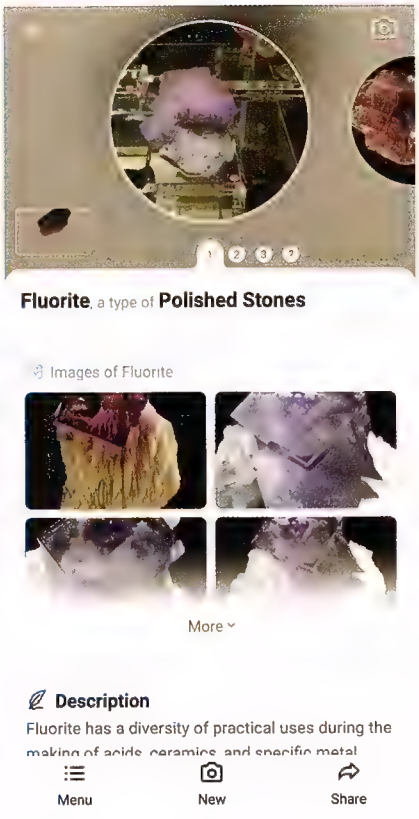
Typewise Custom Keyboard - Big Keys, Emoji & Fonts

Do we really need it?

Free/$38.99

I bet you're sick of regular phone and tablet keyboards that work perfectly well and want to learn an entirely new experience. Well, good news because Typewise may actually make it worth your while. Typewise is a keyboard thats main and first goal is privacy, so if you want to move away from another keyboard that maybe doesn't respect that so much it's a decent choice. However, it goes a bit further, a bit weirder, and a bit cooler than that. Typewise has a specially developed hexagon keyboard that is said to improve typing speeds. It takes some learning but it has a cute tutorial and even a browser-based game you can play to get better. It also has a regular keyboard configuration if you want to keep things simple. What I really enjoy so far is the gesture support. There's tricks for each key but also broader strokes like swiping back to delete. There are a bunch of extra features with a pro subscription but even with just the free version, this app really shows promise. HOPE CORRIGAN

★★★★☆



Android (&iOS)

Rock Identifier

Rock ID.

Free

I think after trying enough plant identification apps, the internet finally decided to throw a Rock Identifier app into my path. The first thing I did after downloading the app was take a photo of a crinkled tissue, the app identified it as a quartz. Next my dog, and the app picked a white fluffy looking crystal and you know, fair. I tried some actual rocks outside but they all came back as petrified wood. One was a river pebble, another was just a big random rock. I don't think any were actually petrified wood. I then tried a few different more gem-style rocks. Tiger eye, jade, and the likes. The hit rate for these was much higher though still a few incorrect answers. I don't think this app will be much help in identifying random rocks you see in the wild, but it might give you some insight into any slightly more collectible specimens. HOPE CORRIGAN

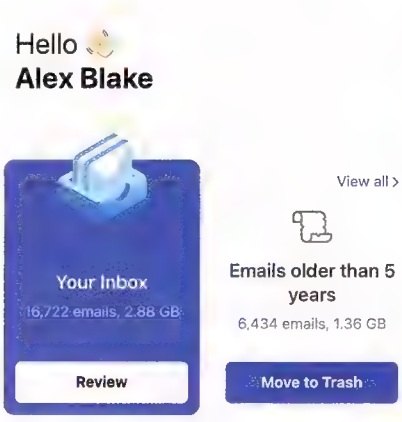
★★★☆☆

"The first thing I did after downloading the app was take a photo of a crinkled tissue, the app identified it as a quartz."

6 apps to declutter your iOS device

Alex Blake helps clear out the cruft and bring some order to your digital life.

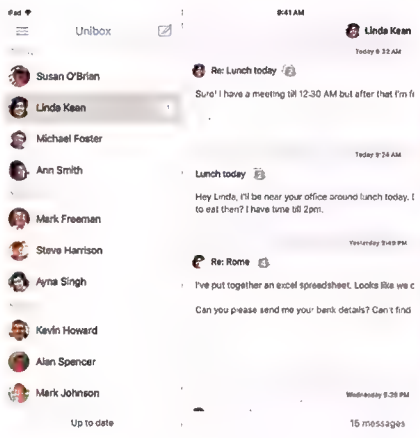
No matter how hard we try, we all accumulate far too much fluff on our iOS devices. That's compounded the longer we use them, with duplicate photos, incomplete contacts, and tons of unwanted emails flooding our devices and eating up storage space. But it doesn't have to be that way. Add a few handy apps to your arsenal and you can quickly reclaim the space and declutter your device for good. Here, we have rounded up six apps that do just that – and best of all, most are free. Set them loose on your iPhone or iPad, and your digital life will be the most ordered and organised it has ever been.



Clean Email

Free (IAPs) | NEEDS iOS 11 or later

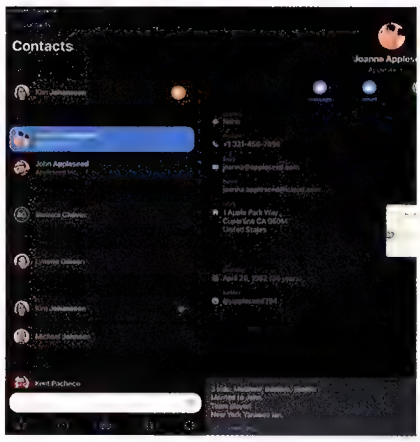
We all amass email newsletters, spam and messages that we no longer need to keep. Clean Email scans your inbox (while protecting your privacy) and sorts your messages into categories for easy clean-up. There's a bulk newsletter unsubscribe tool, plus smart filters and rules to aid scanning. You can even automate the processes to save time in the future.



Unibox

Free (IAPs) | NEEDS iOS 9 or later

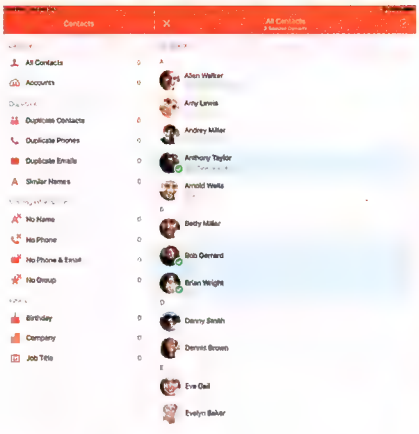
Most email clients quickly become a mess, with multiple messages from multiple senders clogging up your inbox. Unibox takes its cues from instant messaging apps, with your inbox grouped by sender. Messages and attachments are grouped under each person's name, so it's simple to find what you're looking for and easier to sort through the noise.



Cardhop

$7.99 | NEEDS iOS 13 or later

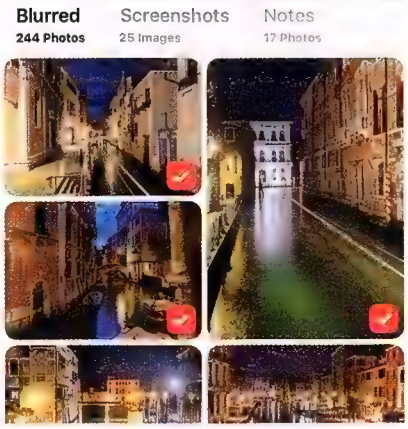
When adding new contacts to your iOS device, if you have a lot of information to add for multiple people it can often feel laborious. By making the process simple, Cardhop helps keep everything neat and orderly. That's thanks in large part to its support for natural language, making data entry easy. It also offers smart groups, quick action buttons, and more.



Cleaner Pro

Free (IAPs) | NEEDS iOS 9 or later

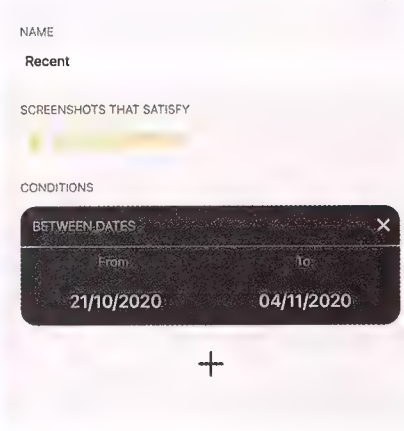
The Contacts app can be an untidy place. Upgrading your phone and importing contacts can be particularly bothersome, resulting in a horde of duplicate and half-empty contacts. Cleaner Pro finds and merges these problem contacts. It does everything in a safe and reversible way, too, so you can always change your mind and undo its work.



Gemini Photos: Gallery Cleaner

Free (IAPs) | NEEDS iOS 12 or later

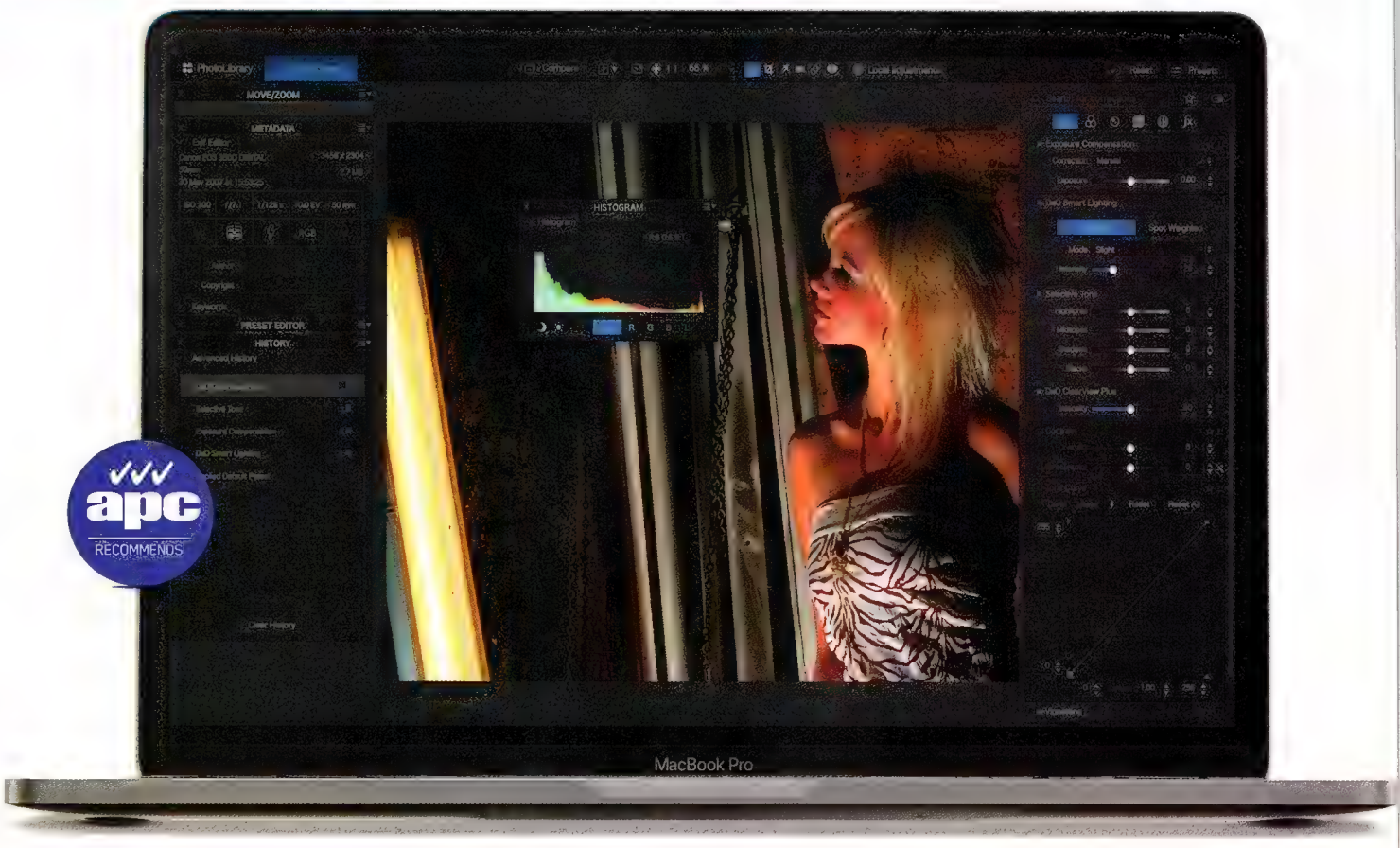
What Cleaner Pro does for contacts, Gemini Photos does for, well, photos. Not only does it scan for exact copies, but it can also unearth similar photos, screenshots, notes, blurred pictures, and other images you might want to remove. It can also suggest large videos that you may no longer need. Removing the excess takes just a couple of taps.



Screenshot PRO

Free (IAPs) | NEEDS iOS 13 or later

While Gemini Photos can clear out unneeded screenshots, Screenshot PRO goes an extra step and helps sort them. You can search for text inside images and export it, add tags, notes, and links; compress large images; lock pics with Face ID or Touch ID; and more. It's ideal if you want to organise images into a manageable collection rather than delete them.



Needs DeepPRIME AI, selective adjustment tools, watermarking feature, support for multiple Raw formats | US $99 | from dxo.com

DxO PhotoLab 4

Reduce the presence of noise and lens distortion.

When shooting in low light, your camera can use a high ISO setting to make it more sensitive to light. However, this can increase the presence of luminance and colour noise in the captured photo. Photo-fixing apps such as Photoshop and Lightroom use lens profiles to help smooth out noise and counteract distortion. What gives PhotoLab 4 the edge is the application of DxO DeepPRIME AI tech.

The app's AI has been exposed to millions of images produced by different camera and lens models. This enables PhotoLab to learn how to smooth out noise without sacrificing detail, reduce the presence of colour fringing (chromatic aberration), and more. We opened a Canon Raw file that had been captured using a high ISO of 3,200. When viewed at 100 percent we could see garish specs of colour noise; after a click on the Denoising Technologies panel's DeepPRIME button, the colour noise vanished. Luminance noise was also smoothed out without losing key details.

As well as using DeepPRIME AI to help fix photos, PhotoLab 4 also downloads Optics Modules (which function like the lens profiles used by apps such as Lightroom). These modules enable PhotoLab 4 to understand particular camera and lens settings used, and enable PhotoLab to improve Raw files snapped on a range of cameras. However, at the time of testing, PhotoLab couldn't process Raw .dng files snapped on an iPhone. This problem applied to older .dng files created by Halide Mark II as well as to newer ProRAW files captured on an iPhone 12 Pro Max.

Up and running

When you first launch PhotoLab 4, you are given the option of turning on auto features. This enables novices to overcome common problems with noise, distortion and vignetted edges with the minimum of effort. More experienced photo editors can choose to use a workspace with less automation, so that they can manually toggle palettes on and off. PhotoLab 4's workspace is designed to look familiar to users of Adobe Lightroom and Photoshop 2021, with a collection of neutral grey palettes that don't distract. You can customise the position of each palette and hide unwanted panels to create a cleaner workspace. PhotoLab 4 can also be added to Lightroom as a plug-in, so you can start editing in Lightroom, then jump to PhotoLab 4 if you need the extra noise-reduction assistance of DxO DeepPRIME.

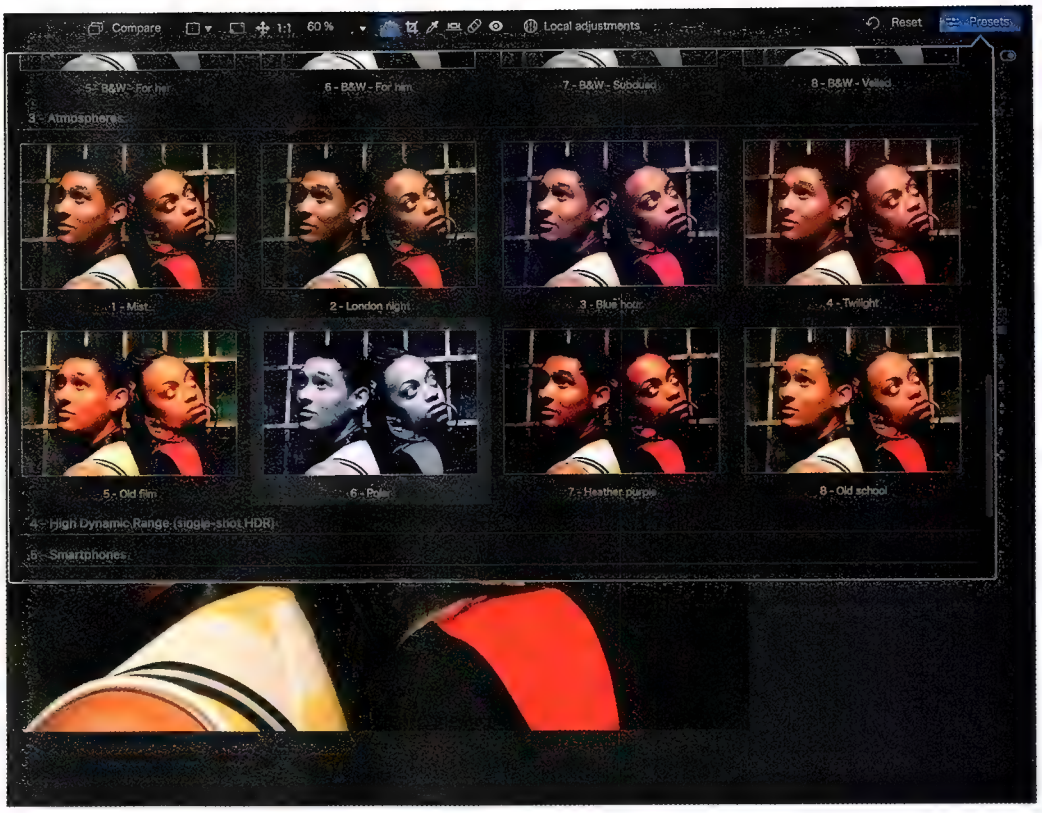
PhotoLab 4's workspace is broken up into tabbed panels such as Light, Colour and Detail. Each panel contains a collection of palettes and tools designed to help with particular issues, such as sharpening soft shots (Detail)

PhotoLab 4 has a host of panels that you can hide or reposition to create a workspace to suit.

or restoring missing highlights (Light). There's a handy Metadata panel that shows the camera settings used to capture the photo. Here you can keep an eye out for noise-inducing high ISO settings, for example.

One of PhotoLab's strengths is its ability to make selective adjustments to Raw files. By going to the Local Adjustments panel, you can control-click anywhere on the image to summon a specific selective adjustment tool. The Graduated Filter enables you to selectively darken overexposed sky without altering the correctly exposed landscape. The Control Point tool enables you to make selective adjustments to a sampled circular area.

After applying a selective adjustment, you can tweak properties via a multifunction equaliser. One of most useful equaliser sliders is ClearView Plus, which alters mid-tone contrast to reveal detail in hazy backgrounds. You can also adjust a specific area using brush tips, which enables you to selectively dodge (lighten) or burn (darken) particular areas with great precision.



To quickly adjust your Raw or JPEG files, browse though a themed collection of one-click presets.

"When you first launch PhotoLab 4, you are given the option of turning on auto features. This enables novices to overcome common problems with noise, distortion and vignetted edges with the minimum of effort."

Get Smart

PhotoLab's Light panel has a useful Smart Lighting feature that does a similar job to Spot Weighted metering. After clicking the Spot Weighted button, you can draw a marquee over certain areas. The app then tweaks the exposure to prioritise details in these areas, and you can fine-tune them by tweaking sliders for Highlights, Midtones and Shadows. You can also access different metering settings such as Highlight Priority or Centre-weighted Average.

You can also quickly reduce the look of barrel and pin-cushion distortion (and ugly colour fringing). However, the app lacks the ability to counteract perspective distortion. You'll need to purchase the separate DxO Viewpoint 3 app to fix perspective distortion but that will set you back an extra $49.99.

If sharing results, you can use the DxO instant watermarking feature. This has seven blending modes to get a balance between viewing the photo without being distracted by the graphic.

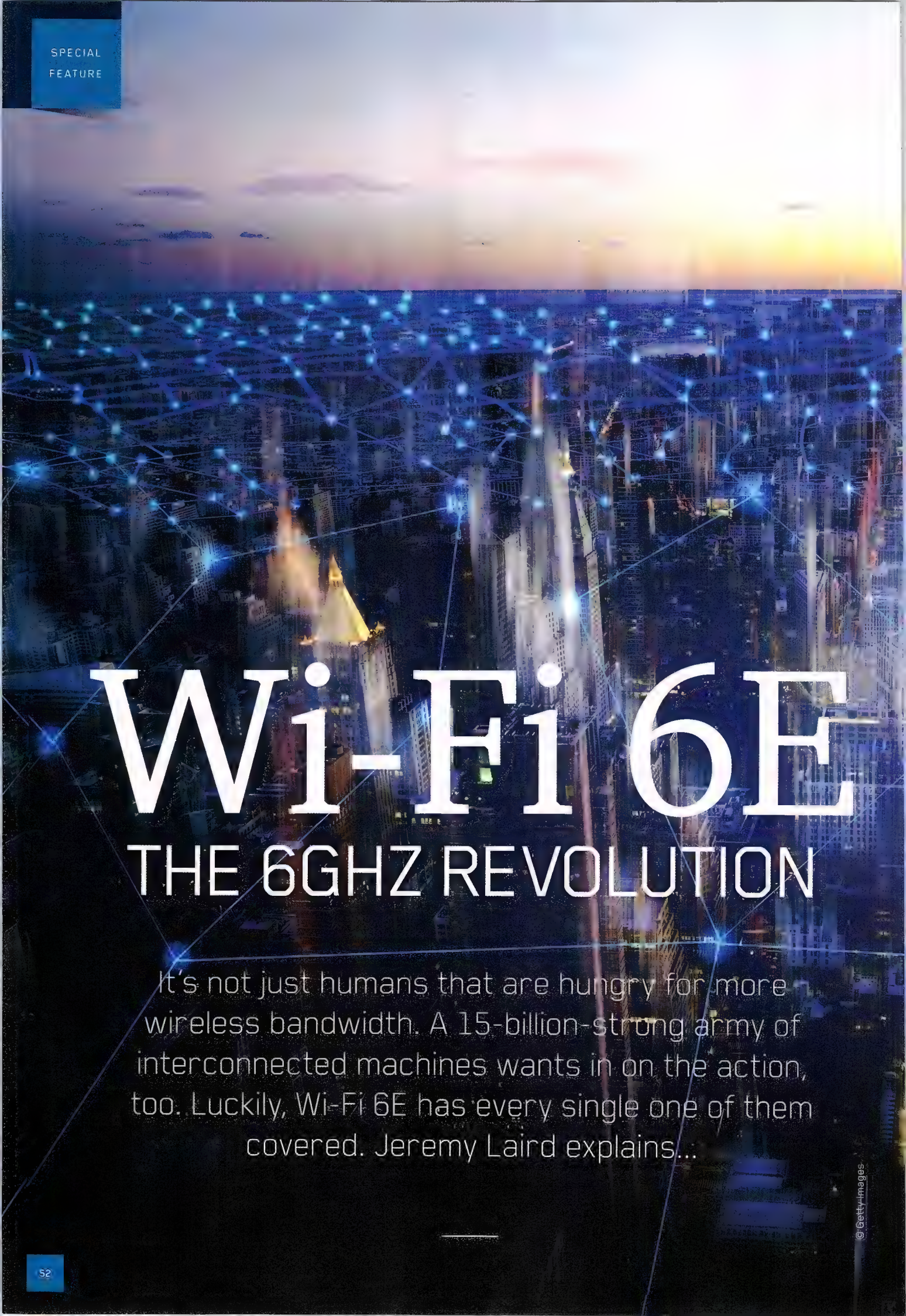
DxO PhotoLab 4 will be attractive to new photographers who will benefit from the AI tools. They'll then be able to experiment with the various manual and selective adjustment tools as their confidence grows. More experienced photographers will probably be happy to stick with Apple's Photos or Adobe's Lightroom app, especially if they want to process Raw .dng files produced on the iPhone. A trial vision of PhotoLab 4 is available to download, so its certainly worth taking it for a test drive.

GEORGE CAIRNS

The Perfect Landscape Guided Edit helps you make good landscapes look great.

If you shoot in Raw then PhotoLab 4's AI assisted tools are a useful asset in your battle for picture perfection.

★★★★☆

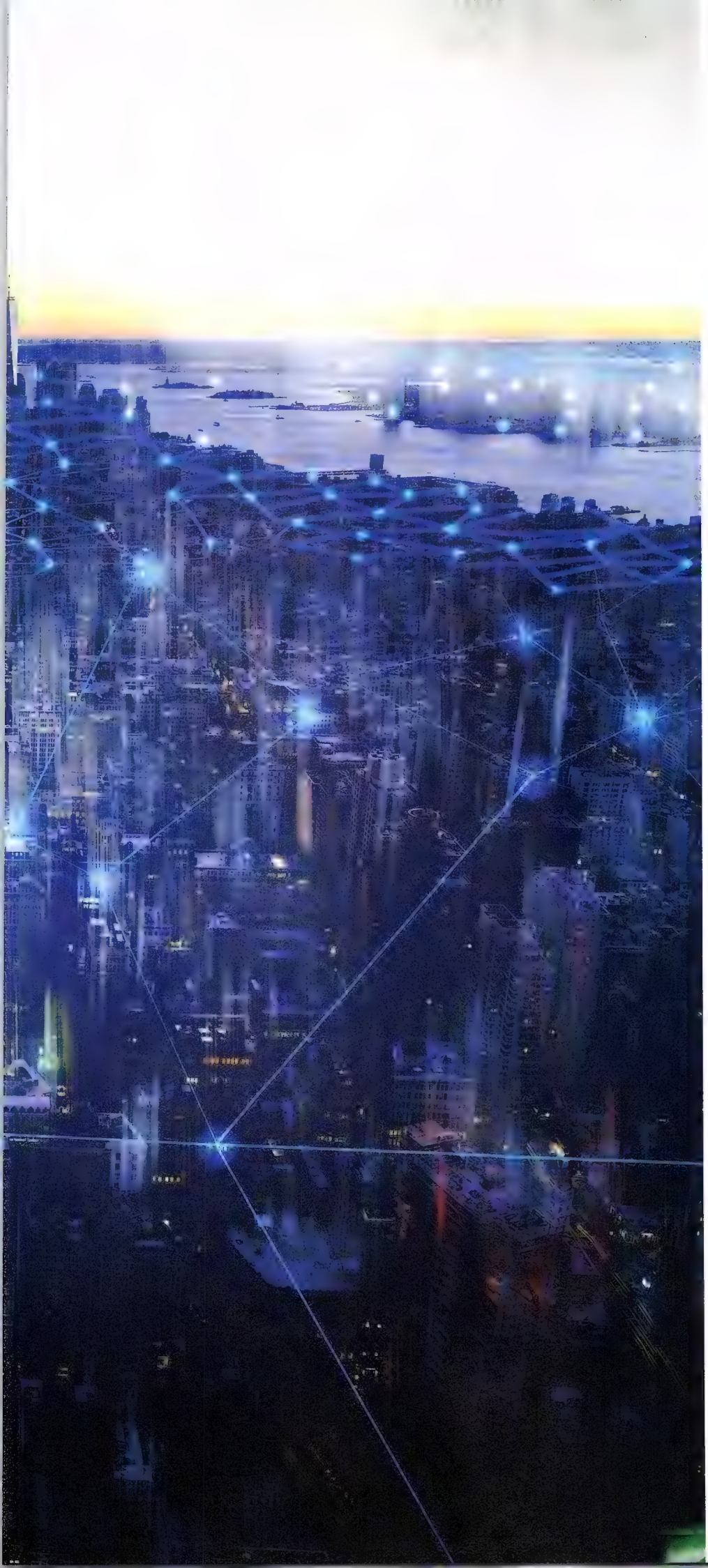


Wi-Fi 6E

THE 6GHZ REVOLUTION

It's not just humans that are hungry for more wireless bandwidth. A 15-billion-strong army of interconnected machines wants in on the action, too. Luckily, Wi-Fi 6E has every single one of them covered. Jeremy Laird explains...

© GettyImages



According to recent research by networking specialist Cisco, nearly two-thirds of the global population will have internet access by 2023. That's around 5.3 billion souls, a huge leap from the 3.9 billion that had access in 2018.

But here's the kicker. Wireless network growth is expected to be even more explosive. Cisco reckons that there were 169 million wireless hotspots globally in 2018, but the number is set to quadruple to 628 million by 2023. That's a whole lot of new Wi-Fi.

Of course, it's not just humans that are bandwidth hungry. In 2018 there were around five billion connected devices that fell into the M2M, or machine-to-machine, connectivity category. In other words, machines talking to each other with no humans involved. In 2023, the number of connected M2M devices is expected to be a colossal 14.7 billion.

The result is a staggering, almost incomprehensible demand for wireless bandwidth. And that's a problem. Anecdotally, anyone who lives in a town or city will be all too familiar with the scroll-inducing litany of options available any time the airwaves are sampled for a list of local wireless networks.

More empirically speaking, there are ever more devices and access points competing for the same relatively narrow wireless airspace. Until now, that is. Because 2021 is the year of Wi-Fi 6E, the biggest step change in wireless technology ever, and the solution, very probably, to the looming wireless connectivity crunch.

Where do we begin?

Billions of new users, tens of billions more devices, most of them wirelessly connected – this is the near future of the internet, and it's incredibly exciting. But it's also a major technological headache. The central problem is airspace. It's over 15 years since the last significant chunk of spectrum was freed up for wireless networking use.

That's right, we're still using the same airspace today as we were when smartphones were barely a thing. At least, that was true until now, thanks to Wi-Fi 6E. In April last year, the U.S. Federal Communications Commission took the momentous step of opening up a huge swathe of bandwidth for unlicensed Wi-Fi use. This year, the first Wi-Fi 6E devices designed to use that epic chunk of new spectrum are coming online.

"This is the most monumental decision around [the] Wi-Fi spectrum in its history, in the 20 years we've been around," said Kevin Robinson of the Wi-Fi Alliance, the industry group overseeing the implementation of Wi-Fi. In one fell swoop, the FCC's decision literally quadruples the amount of airspace available to Wi-Fi networking. The new spectrum has enough room for up to seven simultaneous maximum-capacity Wi-Fi streams, with no interference and without using any existing airspace.

In dispassionate terms, more bandwidth, lower latency, and increased capacity are the immediate technical benefits, with touted applications ranging from whole home gigabit coverage, multi-gigabit Wi-Fi venue capacity, high-speed tethering, low-latency Wi-Fi calling, next-gen VR and AR experiences, and more. But we're getting ahead of ourselves. First we need to get under the hood of Wi-Fi 6E.

In most regards Wi-Fi 6E is merely an extension of the existing Wi-Fi 6 standard. Indeed, the "E" in Wi-Fi 6E stands for "extended" – in this case extended into new airspace, specifically the 6GHz band. Previous Wi-Fi standards have operated in the 2.4GHz and 5GHz ranges.

Prior to that FCC decision, a total of 400MHz of usable space across those two bands has been available for unlicensed Wi-Fi devices. Wi-Fi 6E? It has access to the entire 6GHz band, and then some. The new airspace spans a huge 1,200MHz range from just below 6GHz to a little above 7GHz. In really simple terms, this new spectrum provides far more Wi-Fi capacity than all previous bands combined. It's a dramatic addition.

However, that doesn't mean that Wi-Fi 6E will automatically translate into higher peak speeds or devices. Like standard Wi-Fi 6, Wi-Fi 6E tops out at 9.6Gbps. But that's a theoretical figure, not something you'll get in the real world. Apart from anything else, there are few if any internet applications that supply that kind of bandwidth. Instead, what Wi-Fi 6 is about isn't really top speeds, but improving performance in the context of high densities of access points and devices.

Peak speeds for individual devices are actually likely to improve with Wi-Fi 6E. You can expect real-world speeds of around 2Gbps, which is pretty spectacular. Partly that's down to the inherent advantages of the 6GHz band over 5GHz and 2.4GHz, but it's mostly a function of reduced interference and less congested airspace. Early Wi-Fi 6E devices in particular will have the 6GHz band to themselves,

A desktop PCIe 6E board can bring the new Wi-Fi 6E to your PCs.

making multi-gigabit speeds a reality, rather than a claimed specification you're never likely to achieve.

But rather than hitting the kind of multi-gigabit performance that few users really need, it will be improved reliability in a multi-device environment where Wi-Fi 6E truly delivers. Being able to reliably get the most out of that 300Mbps fibre connection, for instance, or support zillions of access points and devices in densely populated urban areas while maintaining decent speeds, is what Wi-Fi 6E will be really good at.

When Wi-Fi 5 (previously known as 802.11ac) came out in 2013, the average US household had around five Wi-Fi devices. Today, it's around 10, and most estimates predict that number to continue

Wi-Fi 6E around the world

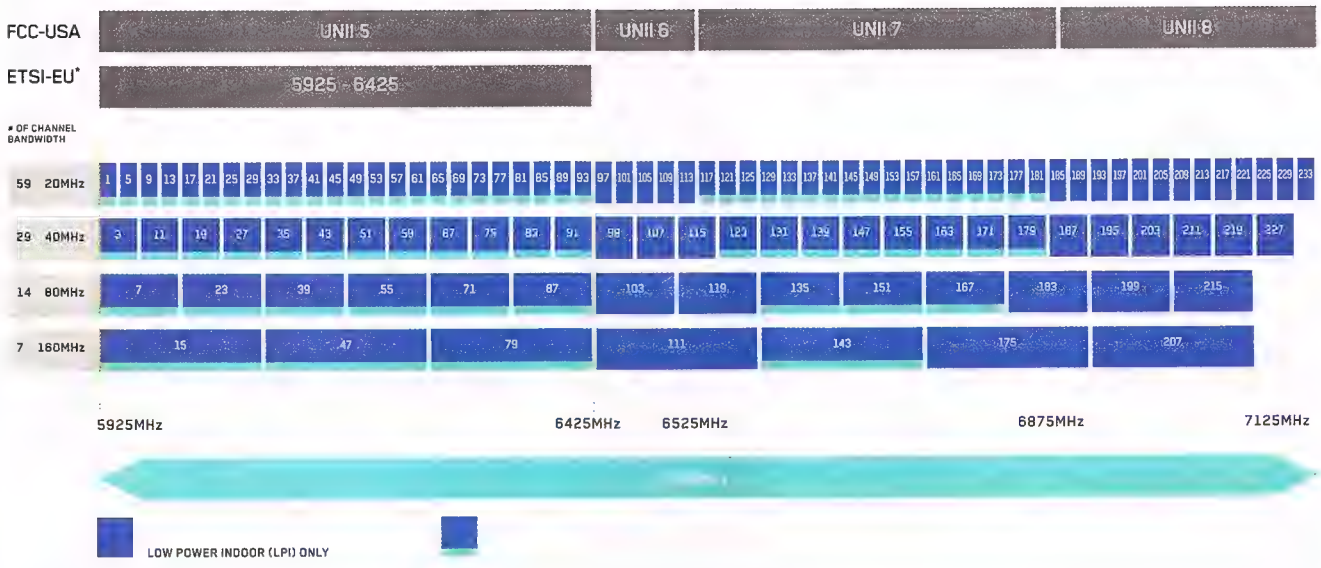
What's happening overseas?

Global momentum behind Wi-Fi 6E is building fast. A number of countries and territories have released or are preparing to release the 6GHz spectrum. Here in Australia the ACMA is yet to approve the band, but it's just a matter of time. The UK, Chile, South Korea, and the United Arab Emirates are on the list of early adopters who have already freed up airspace. Meanwhile, the likes of Brazil, Canada, Mexico, Peru, Taiwan, Japan, Saudi Arabia, Myanmar, and Jordan have begun the process of allocating spectrum.

However, not all Wi-Fi 6E implementations will be equal. For instance, the UK's regulatory body Ofcom has only unlocked 500MHz of new spectrum, specifically 5,925MHz to 6,425MHz. By most measures, that's a large swathe of new airspace. The new spectrum is enough for three new 160MHz Wi-Fi channels, or as many as 24 new 20MHz Wi-Fi channels. But it's a far cry from the 1,200MHz of extra space in the US.

As for countries that have unleashed the full 1,200MHz of spectrum, the second after the US was South Korea. In October last year, South Korea approved 1.2GHz of spectrum from 5,925MHz to 7,125MHz range for unlicensed Wi-Fi use. Soon after Chile became the third country globally and the first in South America to release the full 6GHz band for Wi-Fi 6E.

6 GHz channel allocations



WiFi 6E opens up a tremendous amount of bandwidth.

LPI = AUTOMATIC FREQUENCY COORDINATION (AFC)

* LPI = VERY LOW POWER IN EU

Where are all the Wi-Fi 6E devices?

Get ready for the 6GHz army

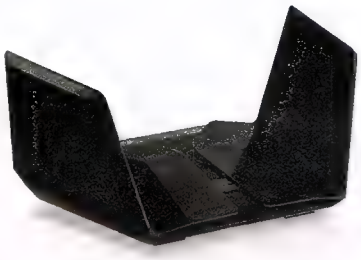
In December 2020, the FCC certified the first Wi-Fi 6E device, a low-power indoor transmitter from Broadcom. By the end of this year, well over 300 million Wi-Fi 6E devices are expected to enter the market.

Inevitably, most of the big brands in wireless are already on board, including Broadcom, Qualcomm, Intel, Samsung, and Netgear. The first Wi-Fi 6E smartphone is the new Samsung Galaxy S21 Ultra. The new handset's Wi-Fi 6E connectivity is powered by technology from none other than Broadcom.

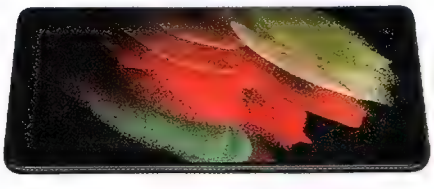
With no fewer than seven Wi-Fi and Bluetooth radios, including support for dual Wi-Fi 6E streams, the Galaxy S21 Ultra is a glimpse into the future of handheld Wi-Fi, capable of around 2Gbps of peak wireless performance along with claimed latency of just a few milliseconds. It can operate across the full Wi-Fi spectrum, including the 2.4Ghz band and all the way from 5.1GHz to 7.125GHz. The Galaxy S21 Ultra also supports all the key Wi-Fi 6E technologies, including super-wide 160MHz channels and MU-MIMO.

Meanwhile, at CES several companies including Netgear, TP-Link, Linksys, and Asus announced Wi-Fi 6E hardware, including routers and mesh systems. The fastest of the lot, at least by the claimed numbers, is the Asus ROG Rapture GT-AXE11000, which is said to be good for 11Gbps. While we doubt you'll see that in the real world, we suspect Wi-Fi 6E kit will get closer to the theoretical maximums than previous wireless kit.

As for device adapters, we haven't seen any Wi-Fi 6E USB dongles yet. But a number of PCIe add-in boards for desktops are available. Intel's Wi-Fi 6E AX210 M.2 card will add Wi-Fi 6E to laptops for a piffling $44.



It looks like an escapee from the *Mandalorian*, but the Netgear RAXE500 was one of the very first 6GHz routers.



Samsung was first out of the gate with a 6GHz Wi-Fi 6E smartphone in the Galaxy S21 Ultra.

Asus's ROG Rapture GT-AXE11000 is the fastest Wi-Fi 6E router yet, with a claimed peak performance of 11Gbps.

"Several companies including Netgear, TP-Link, Linksys, and Asus announced Wi-Fi 6E hardware, including routers and mesh systems. The fastest of the lot, at least by the claimed numbers, is the Asus ROG Rapture GT-AXE11000, which is said to be good for 11Gbps."

© NETGEAR, SAMSUNG, A SUS

increasing. Imagine all those devices in an apartment building, battling for limited airspace that was defined decades ago.

Maintaining speedy Wi-Fi performance in built-up areas, with noisy airwaves full of devices, is already hard. Without the new spectrum, the anticipated uptick in Wi-Fi-connected devices would make a bad situation worse, which is where Wi-Fi 6E's huge new airspace will really deliver.

How does it work?

So that's the broad brush of how Wi-Fi 6E is going to free up capacity, but it's worth digging one layer deeper into the details of how wireless networking works, to understand the mechanics of just how limited the spectrum has been so far, and why the 6GHz band is such a big deal.

At the core of it all are channels, the portions of spectrum over which wireless devices transmit. The 2.4GHz spectrum has 11 channels, each 20MHz wide. However, only three of those channels do not overlap. The 5GHz band ups that to 24 non-overlapping 20MHz channels. That's the basic channel structure. However, multiple channels can also be combined to create a single, wider channel. If you think of channels as physical highways, it's a bit like adding lanes to increase traffic capacity, or in this case data throughput. Remember those impressive peak speeds quoted by Wi-Fi router makers? They're typically achieved using wider channels.

Anyway, the 2.4GHz band supports 20MHz and 40MHz channel widths, while the 5GHz band also supports 80MHz and 160MHz channels. We'll come to the channel structure of Wi-Fi 6E in a moment. So, when a device on a Wi-Fi network wants to transmit, it must wait for the channel on which it is operating to be clear. Only one device can transmit at a time.

There are mitigating technologies designed to enable a certain amount of parallel device transmission on a given channel, such as MU-MIMO, or "multi-user, multiple input, multiple output." However, where overlapping channels are in use, devices on one channel will transmit regardless of the traffic on the other overlapping channels, causing interference and performance degradation. This is known as "adjacent-channel interference" (ACI).

The other type of interference happens when the coverage area of a wireless access point, known as a cell, overlaps with that of another access point running on the same channel. Known as "co-channel interference" (CCI), this creates a single, larger cell that forces any device in the combined cell to wait in turn for the channel to become clear before transmitting. Imagine an access point in a next-door apartment running on the same channel as yours. In terms of network contention, any devices connected to the neighboring access point may as well be connected to yours.

As for how all this applies to the real world, well, in theory wider channels deliver more bandwidth. If you're running a single access point and you don't have any neighbors or other sources of wireless contention, setting your access point to operate over the widest possible channel will give the best performance. Most people, of course, live in built-up areas with numerous nearby wireless networks. In that context, a wide channel is almost guaranteed to overlap with nearby networks and suffer interference. A smaller channel with less overlap and therefore reduced interference can actually deliver better performance.

Now you've got your head around all that, how does Wi-Fi 6E fit in? For starters, it has enough spectrum for 59 fully non-overlapping 20MHz channels. So, the odds of suffering significant interference on a 20MHz channel will be very low for most users. At the other end of the scale, there's space for seven of the highest bandwidth 160MHz channels. Add in existing 2.4GHz and 5GHz channels, and even in a fairly busy urban area Wi-Fi 6E users will have a fighting chance of achieving

6E and 5G

Wireless frenemies

According to some quarters, Wi-Fi 6 and by extension its Wi-Fi 6E cousin will be replaced by 5G cellular technology before they've had a chance to take off. And there's at least some substance behind that narrative.

Historically, cellular networks have been wide-area solutions working at long distance both indoors and out. Meanwhile, Wi-Fi is a short-range technology primarily used indoors. However, with 5G comes a greater use of so-called small-cell access nodes designed to operate over shorter ranges and support fewer devices. That sounds a lot like Wi-Fi. What's more, mid-band 5G networks also operate on similar 2.5GHz and 3.5GHz frequencies to Wi-Fi.

But realistically, you can't put a SIM in every device. 5G networks are also typically installed by telco firms, use specific licensed spectrum, and require fees for access. None of that is a good fit for home or office users installing their own networks.

What's more, data ownership is a major impediment to the idea of 5G replacing Wi-Fi. Put simply, on a 5G network, the carrier owns the data, not you. That has all manner of worrisome implications for businesses wanting to protect their data and use analytics, and raises the prospect of carriers selling data back to clients.

Long story short, 5G and Wi-Fi are complementary and synergistic, not antagonistic technologies. When you dig down into the 5G backbone, you find Wi-Fi as a component part. Likewise, as 5G is increasingly used to provide internet connections to homes, Wi-Fi technology, including Wi-Fi calling over cellular networks, will remain key to enabling seamless connectivity and functionality.

5G shares many characteristics with Wi-Fi 6E, but it's a complementary technology rather than a competitor.

Above left: Intel's 11th gen vPro mobile platform brings 6GHz wireless to professional laptops. Above Right: Intel's Wi-Fi 6E AX210 M.2 card will add Wi-Fi 6E to compatible laptops.

something like the claimed maximum performance figures – which until now were really only relevant for marketing purposes. At the very least that will be true for the first few years, before Wi-Fi 6E hardware becomes more commonplace.

A further corollary benefit that flows from the lack of channel overlapping and contention in the 6GHz band is lower latency. Not only does waiting for a given channel to become clear before transmitting hobble throughput, but that waiting time also increases latency. Some early movers in the Wi-Fi 6E hardware market are making spectacular claims of sub 1ms latency.

That's yet to be proven. But even if sub 1ms isn't achieved, the simple fact of lower contention and less interference will ensure that Wi-Fi 6E still offers major improvements in latency. Will it be enough for truly lag-free gaming, or good enough for VR applications, which are hyper sensitive to latency? That's the promise, and we'll see soon enough. Certainly Wi-Fi 6E will deliver the best wireless VR experience yet.

All that sounds promising, but are there any downsides? One obvious disadvantage of the new 6GHz band is range. Like other Wi-Fi technologies, Wi-Fi 6E transmits in the microwave segment of the electromagnetic spectrum. Microwaves fall between the shorter wavelength infrared spectrum and longer wavelength radio waves.

More generally, higher frequencies imply shorter wavelengths. All other things being equal, shorter wavelengths allow for greater bandwidth, while longer wavelengths enable greater transmission range. That's because shorter wavelength energy is more easily absorbed by materials and matter of all kinds, from walls right through to air particles. Long story short, then, 2.4GHz has the best range, while 6GHz has the best bandwidth. However, the really clever bit is that Wi-Fi 6E is a superset of Wi-Fi 6. That should make the creation of wireless networks that offer the best of both worlds – range and bandwidth – possible.

For example, a mesh network might use 6GHz to connect the extenders or access points at high speed, while using smart algorithms to connect to client devices at 2.4GHz, 5GHz, and 6GHz, depending on range and any physical obstructions. Scaling back to 2.4GHz and 5GHz outside is particularly likely given one of the other shortcomings of Wi-Fi 6E – the fact that the 6GHz spectrum has some licensed users.

However, because Wi-Fi 6E augments rather than replaces existing Wi-Fi standards, any given wireless network implementation will be able to pick and choose among a much wider array of frequencies, bands, and channel widths to deliver the best-possible performance to users in any given scenario. Whether it's physical barriers, local interference, or just a huge number of devices nearby, Wi-Fi 6E brings such a huge increase in usable spectrum that it should have the answer to any situation.

Even when Wi-Fi 6E can't directly improve network performance, it will help free up the airspace for legacy Wi-Fi networks to perform more optimally. The result will be speedier wireless networks for decades to come. It really is that big a step change in wireless technology.

What's in a name?

How does Wi-Fi 6E fit into the Wi-Fi hierarchy?

Wi-Fi 6E is set to be a comms revolution.

Remember the good old days of wireless g, n, and ac? Well, they're gone, replaced by Wi-Fi 4, 5, 6, and now 6E. Of course, much of this is mere rebranding. Under the new nomenclature, what was once rather clumsily known as 802.11g wireless networking is now known simply as Wi-Fi 3. Similarly, 802.11n becomes Wi-Fi 4, 802.11ac is renamed Wi-Fi 5, and 802.11ax is the latest Wi-Fi 6 standard.

But what of Wi-Fi 6E? In simple terms, it's any Wi-Fi 6 device capable of operating in the 6GHz spectrum. In other words, 6E is simply 6 "extended" into the 6GHz spectrum. That definition was made official in January this year when Wi-Fi 6E was certified by the Wi-Fi Alliance, the industry standards body that oversees interoperability and backwards compatibility, and also ensures that Wi-Fi 6E supports the latest WPA 3 security features.

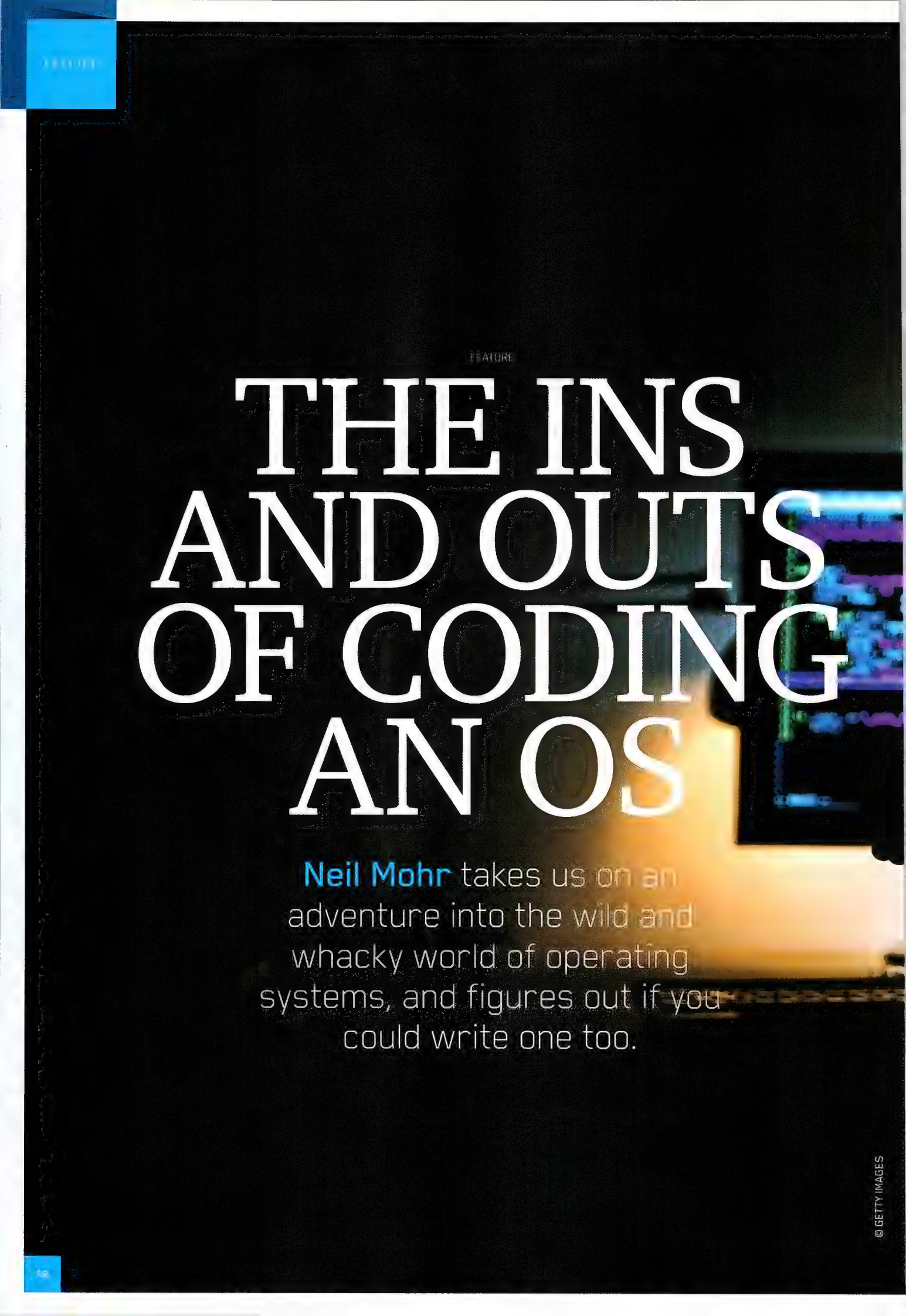
It also means that Wi-Fi 6E adopts the full MU-MIMO capabilities of 802.11ax or Wi-Fi 6. MU-MIMO was already a part of previous Wi-Fi standards. It's a technology that creates support for multiple device transmission on a single Wi-Fi channel, reducing the need for devices to wait for the Wi-Fi channel to which they are connected to become clear before transmitting.

Previous standards supported up to four devices transmitting in parallel. Wi-Fi 6 and by implication Wi-Fi 6E ups that to eight devices. Wi-Fi 6E's status as an extension of Wi-Fi 6 also ensures it will be backwards compatible with existing Wi-Fi access points. However, it won't be possible to upgrade existing Wi-Fi 6 devices to support 6E, be that through firmware or similar avenues.

© Wi-Fi Alliance, intel, Getty Images

THE INS AND OUTS OF CODING AN OS

Neil Mohr takes us on an adventure into the wild and whacky world of operating systems, and figures out if you could write one too.



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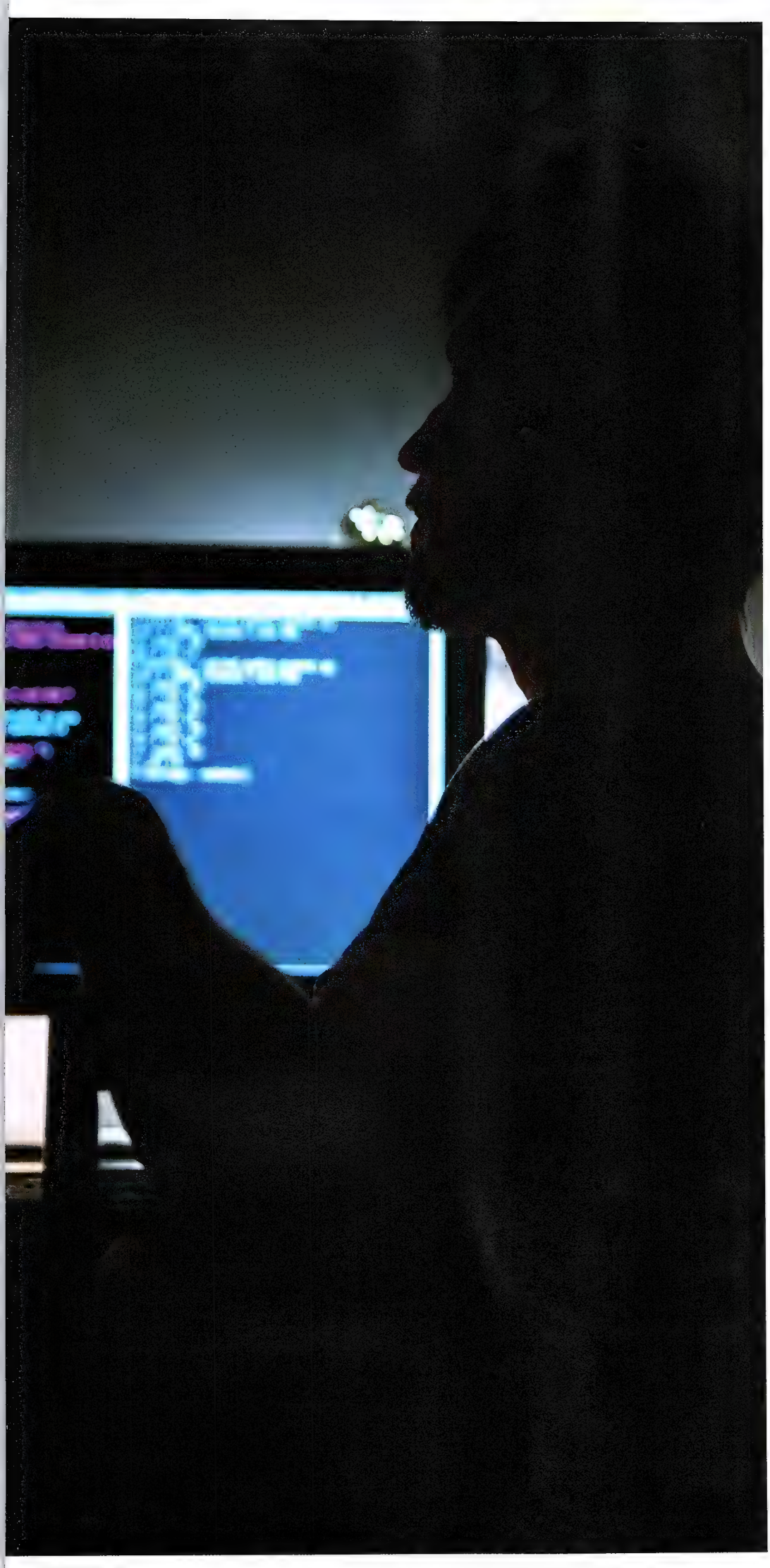


Have you ever wondered what makes a PC start and run, I mean really run? Not just hand-waving "the processor boots the operating system" dismissive nonsense, which isn't any more enlightening than saying that stuff is made of atoms. The nuts and bolts when you press the power button and the PSU fires up its 12, 5, and 3-volt lines to the motherboard – how does the processor even know what to start running, and how is that even loaded into memory when there's nothing to run to do that?

We are talking (semi) software level here. If you want to know how individual hardware components work then that's another world of glorious pain to explore – gawping at the level of insanity of the Intel 8088 architecture that leaves you asking "Why would you do that?" is quite the thing. We have to draw the line somewhere, as otherwise we would be descending into what those atoms are up to inside of all that silicon.

This feature is largely spun out of a thought experiment: If you were locked in a room with just a floppy disk and a PC with a blank hard drive, could you get it to boot and run an operating system? Or more to the point, what would you need to do to run an operating system? We're going to answer that in two parts. To kick things off we'll have a look into that thought experiment: What you need to code to get a booting system. Then we'll actually put together an operating system using the Arch Linux build system, so you can see how all those low-level parts plug together to run a modern operating system. Deep breath, we're going in...

PART ONE

I'm a Windows user get me out of here!

Of course an open-source project has a terrible logo!

It's hard to know just how much we're handled with kid gloves these days as computer users – and this journalist says that from a Linux user's perspective. It's likely that many *APC* readers will remember children's electronic kits from the 1970s, like Radio Shack's Science Fair Microcomputer Trainer. You had to handwire components to create a suitable circuit, then program the CPU by inputting single commands and variables in hexadecimal. Horrifying, but fun!

It's the sort of barebones introduction to computing electronics that will suitably traumatise a young child into wanting to learn to program. It's also about as far away from how current children are introduced to the subject via sanitised iPads and touchscreen devices. Where's all the fun if there's no screaming "What do you mean I have to wire up the resistors with my bare hands just to make it go beep?"

It's this detachment from the underlying (metaphorical) cogs, wheels, and pulleys of computing that triggered the creation of the Raspberry Pi – and let's never forget that Eben Upton only ever expected to sell a few thousand, not 35 million, which tends to indicate that there's some sort of pent-up demand for this low-level access.

We're going to first look at the various parts a PC needs to power up, before it even boots an operating system. Then, once we've covered the building blocks, we're going to move on to installing Arch Linux. This is one of the distros that requires a more "hands on" approach to getting it up and running, but some variants like Gentoo (that requires compiling every element from source) or Linux From Scratch (which is actually a book) take things even further.

To kick things off, the first thing to do is cheat. We're going to presume that our dead PC has a working BIOS. We could try and argue that since this is firmware it's actually more like hardware, as it's baked into the EEPROM, but it's still software. As we'll cover later, without the BIOS you'd have a hard time doing anything: You'd have to first program the EEPROM using a dedicated system, and it's highly tailored to the hardware.

The BIOS is the lowest level that software can interface with the hardware. At initial power on, accessing storage, display, audio, and other peripherals is only possible through the BIOS via interrupt calls. So without it we're a bit stuck.

When you first press the power button, the PSU powers up the ATX cables, so SATA drives are directly powered, the motherboard, and GPU. The PSU can take a second or so to build a reliable power supply, and the chipset generates a reset signal for the processor (as if you're pressing reset) until it gets a Power Good signal from the PSU. Devices such as memory have fixed logic and will initialise; more complex devices such as a GPU or network cards will have their own firmware that will initialise.

```
Ubuntu
Advanced options for Ubuntu
Memory test (memtest86+)
Memory test (memtest86+, serial console 115200)
XCP-ng 8.1.0 (on /dev/nvme1n1p1)
Advanced options for XCP-ng 8.1.0 (on /dev/nvme1n1p1)
*Windows 10 (on /dev/sda1)
Ubuntu 18.04.4 LTS (18.04) (on /dev/sda5)
Advanced options for Ubuntu 18.04.4 LTS (18.04) (on /dev/sda5)
Ubuntu 20.04 LTS (20.04) (on /dev/sdb3)
Advanced options for Ubuntu 20.04 LTS (20.04) (on /dev/sdb3)
```

Our *APC* test machine sporting a number of OSes.

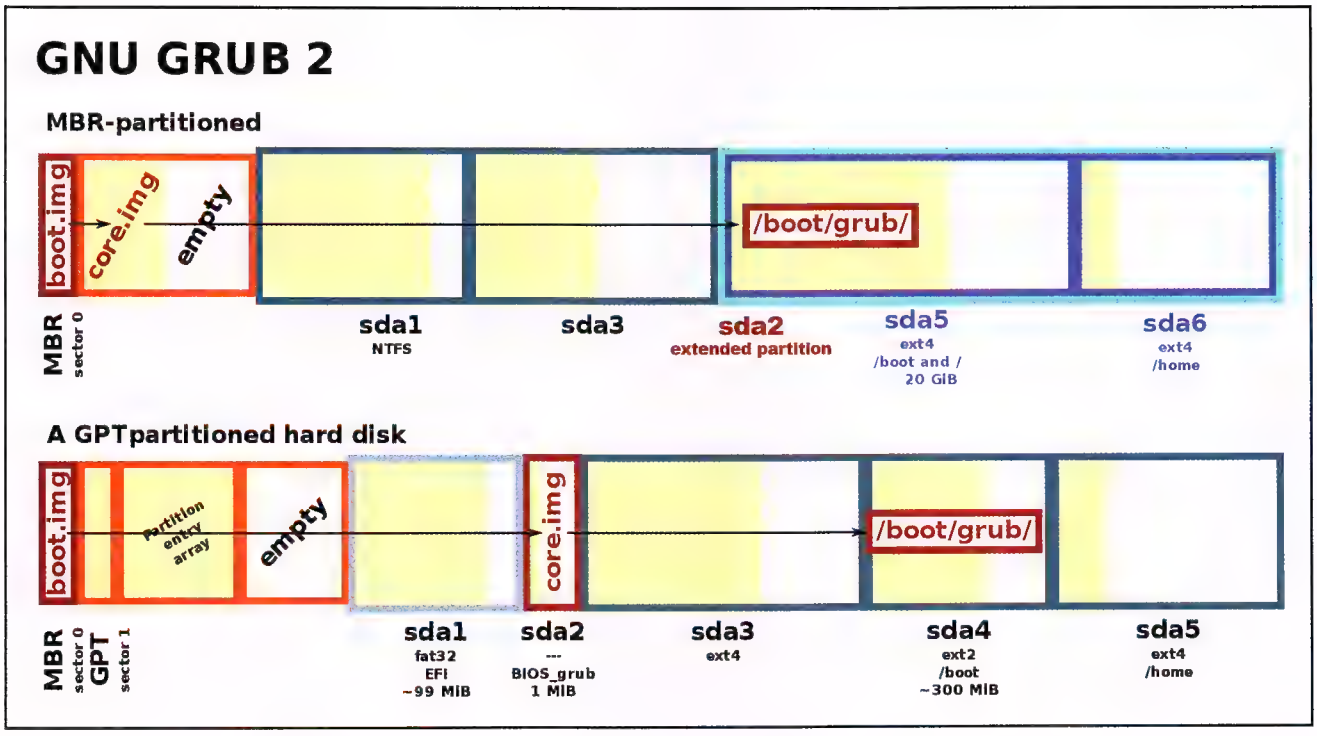
The reset signal is released, and the CPU powers up with a randomly selected single core, but requires something to run since the memory is blank. The original behavior is to have the first instruction mapped from EEPROM memory to 0xFFFF0h (1MB) – the maximum memory for 16-bit minus 16 bytes – the modern behavior is 0xFFFFFFF0h (4GB) – the same but for 32-bit address space. That first command, called the reset vector, is always a long jump to where the BIOS is actually located – usually 0xF00000.

At this point your PC can run its Power On Self Test software. This largely initialises CPU registers, verifies the BIOS, verifies DMA, the timer and the interrupt controller, verifies system memory, and verifies boot devices. On modern systems this extends to verifying all system buses (USB, PCIe etc), devices and, displays. It also initialises the Advanced Configuration Power Interface (ACPI), setting the data in memory for use by the operating system kernel.

If a serious error is encountered that stops the system boot proceeding, the BIOS can communicate that in a number of ways: A screen error message or code; a series of audible beeps; or it can transmit an error over the PCI bus to a suitable debug card.

But if, as is often the case, everything goes well, then the BIOS is ready to hand off control of the PC to an operating system, but how? All that verifying buses and devices comes in rather handy at this point, as it'll have a list of supported storage devices attached to detected buses. In the olden days this would just be the floppy drive, or the primary IDE hard drive. Today it could have a huge list of possibilities, as many of you might know from your own UEFI boot options.

© GRUB, SHMUEL CSABA OTTO TRAIAN/WIKIPEDIA, GRUB, POLYLITH



Here's a visual of how Grub transverses its multi-stage bootloader from MBR, root partition, config file to OS kernel.

It doesn't matter if it's an NMVe or a USB stick, the hand-off sequence is the same: The BIOS loads the first 512 bytes from the selected boot device – what we call the Master Boot Record (MBR) – it's literally the first sector of a drive and is loaded into memory and directs the processor to run this code. The 512 bytes is even more limited than you'd think, as it also has to contain the basic partition table, limited to just four – one that can be marked as the "Active" boot partition, plus an end Boot Signature of 0x55, 0xAA that shows the drive is bootable.

As you can imagine, this isn't any space to do much more than redirect the processor to where there's more code to run. So the MBR is often called the Stage One Bootloader. On standard Windows systems the code directs the BIOS to load the first sector – so another 512 bytes – of the active-marked partition in the partition table into memory, and run that.

As an aside, be aware that UEFI firmware has supplanted the MBR on modern PCs, as the UEFI can directly understand drive and partition layouts and can store boot code on a FAT32 partition, doing away with the MBR's limitation – a major limit to the MBR being a 2TB multi and 4TB single-partition limit, though MBR remains backwards-compatible with (U)EFI systems.

Are we there yet?

We're getting there, the fuse is burning but the main event hasn't quite ignited. At this point the MBR code loads the first three bytes of the active-partition's first sector. This is a JMP command telling the system how far ahead to go to load the Second Stage Bootloader, and we can almost start our operating system kernel.

The main aim of the Second Stage bootloader is to load its configuration file, present any required user menu, and then to hand off to the operating system kernel with any required options – often recovery modes or older kernels. As this bootloader is required to access a file as part of a high-level file system (FAT32, NTFS, ext2/4) there's a lot more complexity.

You would imagine it'd be easy to use hard-coded settings in many areas of this boot chain, but while it could work, it wouldn't be very flexible, and a single change would cause the entire thing to fail. All the major bootloaders store a configuration file that's loaded at boot-time from which any boot options are created.

This is how we entertained ourselves in the 1970s...

Windows NT, 2000, and XP used the NTLDR bootloader that stores a boot.ini file on the root of the active partition. It also used the NTDETECT.COM tool to detect devices. Windows Vista and onwards use BOOTMGR, which maintains a BOOT folder with a BCD (Boot Configuration Database) binary configuration file. BOOTMGR was designed to support modern GPT and UEFI configurations, and its BCD cannot be edited by hand.

Most open-source OSes use Grub 2 (GRand Unified Bootloader). Released in 2012, this stores a grub.cfg in a /boot/grug/ folder either on its own boot partition or in the base folder of the boot operating system.

Many Windows users won't notice anything, and Windows will start up. However, your Second Stage Bootload can support multiple operating systems on a single system in a multi-boot format. Selecting the OS you want to boot kicks off the final stage of the bootloader process.

Depending on the OS and type of kernel, the bootloader will load the kernel image from the path specified in the configuration file into the memory. It points the CPU to JMP to a certain location within the kernel and starts running the operating system.

PART TWO

Let's build an OS!

In an old Reddit thread someone once asked, "If you were locked in a room with a PC with no OS, could you write one from scratch?" Among all the joke replies, someone actually answered that question – Kragen Javier Sitaker, who worked for Canonical (the company that publishes Ubuntu) at the time.

Sitaker's approach took a number of steps to implement the base functionality that's needed to get an OS up and running, though this hinges on there being a functioning IBM PC-compatible BIOS. He then piggybacked off the bootloader to implement his base features.

On the previous spread we alluded to the BIOS providing base access to devices. This is done via interrupts, and enables the minimal bootloaders to get an OS kernel up and running, and indeed enable the kernel to bootstrap itself into life. Interrupt calls cover everything from writing to the screen (10h), read/write to storage devices (13h), serial port access (14h), read the keyboard (16h), and access the PCI bus (1Ah).

Using the Intel 8088 ah and al registers, you could print a "!" character to the screen using screen function 0Eh and interrupt call 10h in assembler like so:

```
mov ah, 0x0e      ; function number = 0Eh : Display Character
mov al, '!'       ; al = character to display
int 0x10          ; call INT 10h, BIOS video service
```

You hopefully get the picture, or else trust us that you can get the BIOS to do basic stuff, otherwise how else do you think BIOS menus were created and managed?

To get anywhere with this, the first thing you need is a way to enter machine code into the computer and jump the processor to it. This is called a machine code "monitor." They used to be all the rage, but for some reason have fallen out of favor with the kids, but Sitaker wrote a super-basic one in C like this:

```
int main(int argc, char **argv) {
  for (;;) {
    char c = getchar();
    if (c == '.') return 0;
    char d = getchar();
    putchar(((c & 0xf) << 4) | (d & 0xf));
  }
}
```

The getchar() and putchar() are BIOS interrupt calls. If you want to look it up, AH = 01h, Int 21 reads a character with echo, while for getchar() and AH = 02h, Int 21 writes a character to standard output.

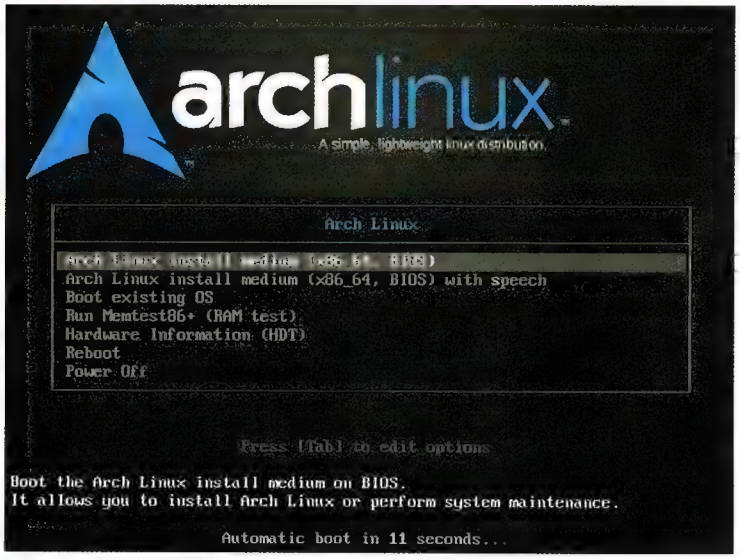
In the magic scenario you have to hand, translate this into assembly, and then machine code and somehow get it onto the bootsector of your floppy. Let's do some hand-waving and pretend that's part of the rules.

If you're feeling brave, try **linuxfromscratch.org**

With this, the PC would now boot the super-basic machine code monitor into memory and run it. At this point you'd want to write the monitor to the main area of the floppy, but enhance it with "modern" features like backspace, displaying what you're entering, and other basic editor features. Displaying areas of memory, changing the target address, and interrupting looped code would all be on your To Do list. Adjust the first-stage bootloader to JMP to this new monitor on the floppy, and you're cooking with machine code.

Typing pure machine code octal by octal is no fun, even in your swanky feature-ladened monitor. So the next step is to create a basic assembler. We'll start to plough through these, but the assembler lets you code with case-sensitive letters for instructions. Write this in your monitor and save it to a blank area on your floppy.

But even assembly is a pain, so


archlinux
A simple, lightweight linux distribution
Arch Linux
Arch Linux install medium (x86_64, BIOS) with speech
Boot existing OS
Run Memtest86+ (RAM test)
Hardware Information (HDT)
Reboot
Power Off
Press [Tab] to edit options
Boot the Arch Linux install medium on BIOS.
It allows you to install Arch Linux or perform system maintenance.
Automatic boot in 11 seconds...

Left: Kicking off an Arch Linux install.
Below: As for many things use a virtual machine.

© LINUX FROM SCRATCH, ARCH LINUX, ORACLE, GNU, MENUETOS

to speed development of your proto OS you'll first want to develop a high-level language, Sitaker used Forth, but it really doesn't matter. If you're wondering, Sitaker has a 66-line, self-compiling Forth working example here **https://github.com/kragen/stoneknifeforth**.

With that safely on your floppy, you'll want to create a minimal file system so you can create, load, and develop new commands in your Forth editor without the worry of overwriting things. You'll then want a basic set of commands for managing those files – delete, move, rename, list files, and copy. A basic compression tool would help speed things along, and why not redevelop your assembler and implement a text editor rather than editing memory directly?

Currently, and we've not mentioned it, everything here is running in Intel's 16-bit real mode, which is sort of the 8088 fallback mode. That's right, it's not very good. If you wanted to go on and develop this further you'd want to re-compile everything now to work in 32-bit protected mode, which enables full memory space access, along with strict memory and I/O protection.

You can go to set the screen via the BIOS to 640x480 in 16 bits, develop libraries to draw primitives, manage these as windows, create a desktop system to keep them all on, monitor a mouse pointer, and Bob's your proto-OS.

Enter the Arch

To put all this "fun" behind us but continue on our quest for a working operating system, we're going to continue with Arch Linux. Arch has a reputation among Linux distros for being in-depth and has coined the meme "I use Arch btw," as some users tend to throw it around as a mark of superiority. It's a very nuts and bolts distro, expecting you to do much of the configuration, and you'll need to install a GUI desktop, if you want one. But it has the best documentation on the planet, and its software repositories are the most up to date, with it generally being the first distro to make new kernels and software available via its rolling update system.

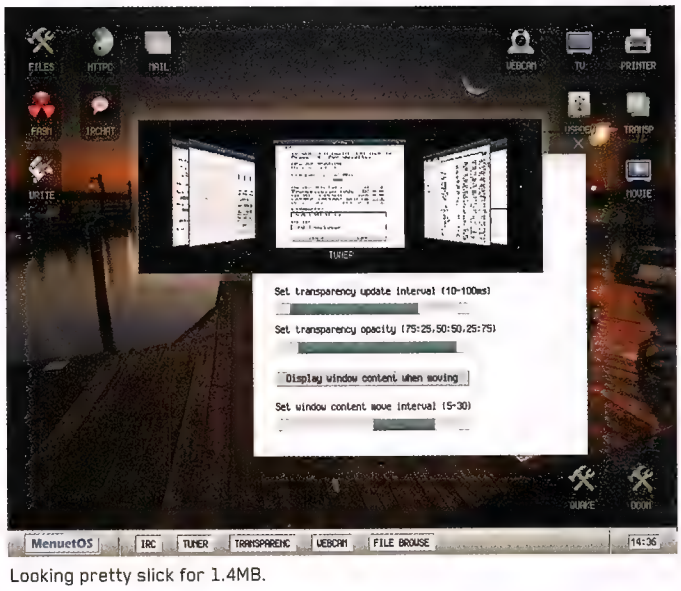
So if truth be told, this guide isn't going to be much more than a targeted rewrite of the core install guide (which you should check out at **https://wiki.archlinux.org/index.php/installation_guide**). We'll focus on installing on a VirtualBox machine and so specify settings and cut some corners to fit that.

"In the magic scenario you have to hand, translate this into assembly, and then machine code and somehow get it onto the bootsector of your floppy."

Bless GNU

If all of this sounds super-crazy, back in 1983 Richard Stallman created the GNU Project (GNU is Not Unix), and the first items to be developed were the GNU C compiler GCC (it remains one of the leading compilers today), the EMACS text editor, the GNU Coreutils (file manipulation), the GNU Bash shell, and the GNU C library glibc, which provides the basic function calls to enable C to work on a system. All of these tools developed 35 years ago are still used within most open-source operating systems to one degree or another today.

So while this might seem just a bit of silly fun, it does genuinely outline the basic building blocks and steps required to boot a computer. And absolutely with older BIOS systems this is the process, and as you can imagine, there was very much a need for the UEFI system to replace all this antiquated bootstrapping. It also turns out that if you're a seriously gifted coder it can work – like Kragen Javier Sitaker, who just for fun implemented and tested this process in DOSBOX and got it to work. Mind blown.



Looking pretty slick for 1.4MB.

The weird alt OS world

Haha, fit a graphical OS on a floppy disk, crazy talk, right? It is until you go and look at **http://menuetos.net** which is a graphical OS that fits on a floppy disk. Like many of these alternative tiny operating systems, it's entirely written in assembly and yet supports 64-bit CPUs, 32GB of RAM, USB 2.0 devices, a full TCP/IP stack, full GUI toolkit and 1080p in 24-bit colour. But can it play Crysis? No, no it can't. There is a small but active world of alternative operating systems. Some like AROS.org are education-based projects spun out of an older operating system, an API-compatible implementation of AmigaOS but entirely open source and for modern hardware. Others like MikeOS (**http://mikeos.sourceforge.net**) are created by highly intelligent people that fancy the challenge of creating an entire OS from scratch. While perhaps standing on its own is TempleOS.org (rest in peace Terry A Davis) created as a literal mission from God written in assembly and its own HolyC language.

PART THREE

Installing Arch Linux

Before you can do anything you'll want to start the ISO downloading for the Arch Linux install image. Head to **www.archlinux.org/download** and grab one of the torrents, or else scroll down to one of the localised mirrors.

Best practice is to run an integrity check on the download file – this ensures that it's downloaded correctly but also that no one has interfered with the stored file. Technically the ISO file and checksum hash should be stored on different systems, so it's harder to compromise both.

The easiest way is to use a hasher, such as IgorWare Hasher (**www.igorware.com/hasher**) for Windows types, load the ISO file and click "Calculate." The generated SHA-1 and MD5 hash should match that on the Arch Linux download page. You can copy and paste it to save you reading a long hexadecimal number.

If you're thinking of installing this onto a real PC then you'll need to burn the ISO to a CD/DVD (remember those things) or more likely use Etcher.io to write it to a USB stick. Reboot your system, and activate its boot menu via the correct function key, usually one of F2, F10, or F12 to boot your PC from the USB device.

We're going to opt for the sensible angle of installing using a **VirtualBox.org**. Create a new 64-bit machine, ideally with 4GB of memory, but 2GB or even 1GB is fine. Set a hard drive of at least 20GB, ICH9 chipset, VMSVGA graphics, 3D acceleration won't hurt. Point the optical drive at the Arch ISO image and fire it up.

At the Arch Grub – remember that? – boot menu choose the top option to kick off installation. Typically you'd first set your keyboard mapping so you can type in stuff – as it defaults to the US, we're all good. If you need to, list the available keyboards (there are a lot, you probably want the /qwerty/ folder) with:

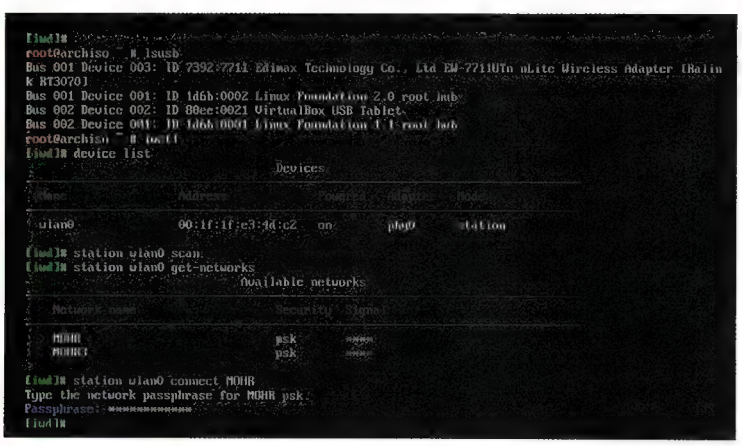
ls /usr/share/kbd/keymaps//*.map.gz | more**

And activate the one you want with loadkeys **<keymapname>** for example: **loadkeys uk**

We should also check what type of firmware the PC is using, EFI or BIOS/CSM. To see if the EFI folder exists, type: **ls /sys/firmware/efi/efivars**

If it does exist you're on an EFI system, if not it's the old BIOS. This changes the partition layout required. If you were expecting something different you'll need to check your UEFI settings – for our VirtualBox it's using the old BIOS by default. If you want, you can create VirtualBox machines running EFI. To run updates, the system will need an active network connection. For VirtualBox systems and most PCs with a wired Ethernet connection this'll just be up and running, and the DHCP will be active. You can test it via: **ip link** and: **ping archlinux.org**

If you're on actual real hardware with a wireless adaptor you'll need to connect to a network.


root@archiso ~ # lsusb
Bus 001 Device 003: ID 7392:7711 Edimax Technology Co., Ltd EW-7711UTn nLite Wireless Adapter [Realtek RT3070]
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 002: ID 80ee:0021 VirtualBox USB Tablet
Bus 002 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
root@archiso ~ # iwctl
[iwd]# device list
Devices
wlan0 00:1f:1f:e3:4d:c2 on phy0 station
[iwd]# station wlan0 scan
[iwd]# station wlan0 get-networks
Available networks
MOHR psk ****
MOHR5 psk ****
[iwd]# station wlan0 connect MOHR
Type the network passphrase for MOHR psk.
Passphrase: **********
[iwd]#

Setting up a wireless connection Arch Linux style.

You should check to see if the hardware is recognised and working. If it's not you're a little bit stuck, as adding kernel modules is outside this tutorial, though it's not hard: Discover the hardware manufacturer and model, search for and download the kernel module (the driver), and add the module via modprobe **<module name>** .

An easy ways to check for an internal PCI adaptor is to use: lspci and look for a wireless network device. For USB dongles use: **lsusb** and do the same. Adding a wireless network is more involved: With the Intel-developed configure tool, type: **iwctl**

This provides an interactive prompt, type **help** at any point, use Tab to autocomplete commands and station names. A basic session (ignore #comments) would go like:

device list #lists compatible wireless devices

station <device name> scan #scan for SSIDs on the selected device

station <device name> get-networks #list detected SSIDs

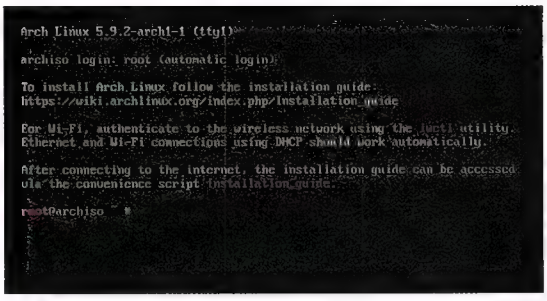
station <device name> connect <SSID name> #connect, you'll be prompted for the passkey

Exit #takes you back to the prompt

At this point you're good to prepare the main drive, create the partitions, and initialise the filesystems. BIOS and UEFI systems have two slightly different layouts: UEFI ones require a dedicated FAT32 partition for the second stage bootloader as the first partition, whereas BIOS just requires the root storage partition – often there's a second for swap, but that's growing out of fashion.

To list all attached block storage devices, type: **lsblk**

Ignore "loop" and "rom," we just want "disk" types. For our VirtualBox example and SATA-based PCs this device is sda; for NVMe and flash-storage devices this is **nvme0n1** and **mmcblk0** – yes, zero naming consistency, welcome to Linux.


Arch Linux 5.9.2-arch1-1 (tty1)
archiso login: root (automatic login)
To install Arch Linux follow the installation guide:
https://wiki.archlinux.org/index.php/Installation_guide
For Wi-Fi, authenticate to the wireless network using the iwctl utility.
Ethernet and Wi-Fi connections using DHCP should work automatically.
After connecting to the internet, the installation guide can be accessed
via the convenience script installation_guide.
root@archiso ~ #

This is what most people think Linux looks like, they're right!

Similarly, using the old DOS partition tool fdisk, type fdisk -l for a bit more information. To kick things off, type the full path of the device you want to set up: fdisk /dev/sda

First, create your two new partitions in order: The small EFI one and the main Linux root. You can skip this first one for BIOS systems, but it'll work either way. Tap **n** to create a new partition **n** , **p** for primary, Return for default, Return for default, and **+512M** to make it 512MB in size. Tap **t** to change the type and select EFI for us this is type **ef** .

To create the main root partition, type **n** , default, default, default, default to use the whole remaining space. Type **w** to write these changes and exit. It's now necessary to create the filesystems; the EFI one is FAT32 while the main one is the Linux native ext4 format.

```
mkfs.fat -F32 /dev/sda1
mkfs.ext4 /dev/sad2
```

The partitions have been created, formatted, but Linux requires specific partitions to be mounted to make them accessible. For the EFI two partition setup this will be the /dev/sda2 partition.

```
mount /dev/sda2 /mnt
```

Before you trigger the main install process, you need to ensure that the mirrors are the best available for our locality. You're going to run a number of commands to prep the install for updates.

Pacman is the Arch Package Manager tool – you'll use this a lot if you stick with Arch. First, synchronise the main repository ready for installing software, install a tool called reflector, and use it to ready a list of the 12 latest, fastest US mirrors.

```
pacman -Syy
pacman -S reflector
reflector -c "US" -f 12 -l 10 -n 12 --save /etc/pacman.d/mirrorlist
```

The majority of the packages can be installed via the pacstrap script. Leave this to download all the base files and get a cup of coffee. If it fails or stall you can simple re-run it:

```
pacstrap /mnt base linux linux-firmware nano
```

At this point the base OS is installed, but you have to do some tedious but necessary housekeeping. The first item is to store the partition mount configuration in the FilesystemTable, or fstab, so the OS knows what to mount at boot time. You're currently still running off the ISO image, change root with chroot to your newly installed /mnt and then set the timezone settings. Choose a suitable timezone, or use the UTC.

```
genfstab -U /mnt >> /mnt/etc/fstab
arch-chroot /mnt
timedatectl list-timezones
timedatectl set-timezone UTC
```

Another set of settings that is often taken for granted is the locale. This defines the language, number system, date format, and default currency. This is a little messy, but you need to first edit a large config file of possible locales.

```
nano /etc/locale.gen
```

Locate the line **#en_US.UTF-8 UTF-8** and remove the # and press Ctrl-O (output) to save and Ctrl-X to exit. Then finish it off with:

```
locale-gen
echo LANG=en_US.UTF-8 > /etc/locale.conf
```

Now to set the base local networking settings that are rarely considered. First, create a hostname for your system; the "pcname" can be anything you like:

```
Echo pcname > /etc/hostname
nano /etc/hosts
```

The last command fires up a text editor with a new hosts file, add to it these lines, and remember to change "pcname." Press Ctrl-O to save (output) the file and then Ctrl-X to exit:

```
127.0.0.1   localhost
::1         localhost
127.0.1.1   pcname
```

Finally, initiate the network manage, and set a password for the base admin account – the username is root:

```
systemctl enable NetworkManager.service
passwd
```

And finally (really this time), we have to install the Grub bootloader on our non-EFI system. It takes three commands: The first installs Grub itself, the next installs Grub onto the boot partition, and the final one creates the bootloader config file it'll need when kicked into life.

```
pacman -S grub
grub-install /dev/sda
grub-mkconfig -o /boot/grub/grub.cf
```

If you were on an EFI system things would look similar but require extra steps to create the /boot/efi folder and mount the boot partition like this:

```
pacman -S grub efibootmgr
mkdir /boot/efi
mount /dev/sda1 /boot/efi
grub-install --target=x86_64-efi --bootloader-id=GRUB --efi-directory=/boot/efi
grub-mkconfig -o /boot/grub/grub.cfg
```

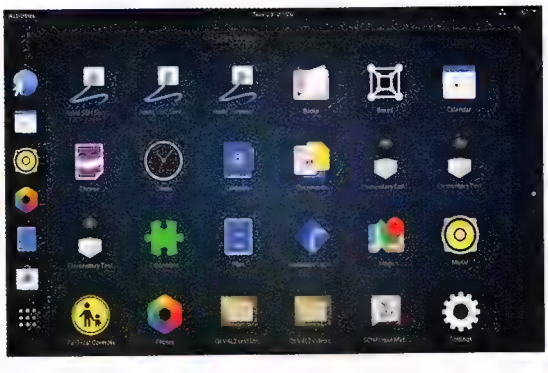
At this point you could reboot – remember to remove the ISO image – and log into your Arch install. You'll be left at a command prompt, but you have a Linux install that powers a good portion of the internet. However, as we're here we might as well install the standard GUI called Gnome. We'd love to delve into just how mind-numbingly complex modern graphical interfaces are, but instead we'll just let you gawp at the 2GB install triggered by these two commands:

```
pacman -S xorg
pacman -S gnome
systemctl start gdm.service
systemctl enable gdm.service
exit
shutdown now
```

Remove the USB stick or ISO image file, fire up your Arch install and log in as root using your password and welcome to Arch Linux using the base Gnome interface.

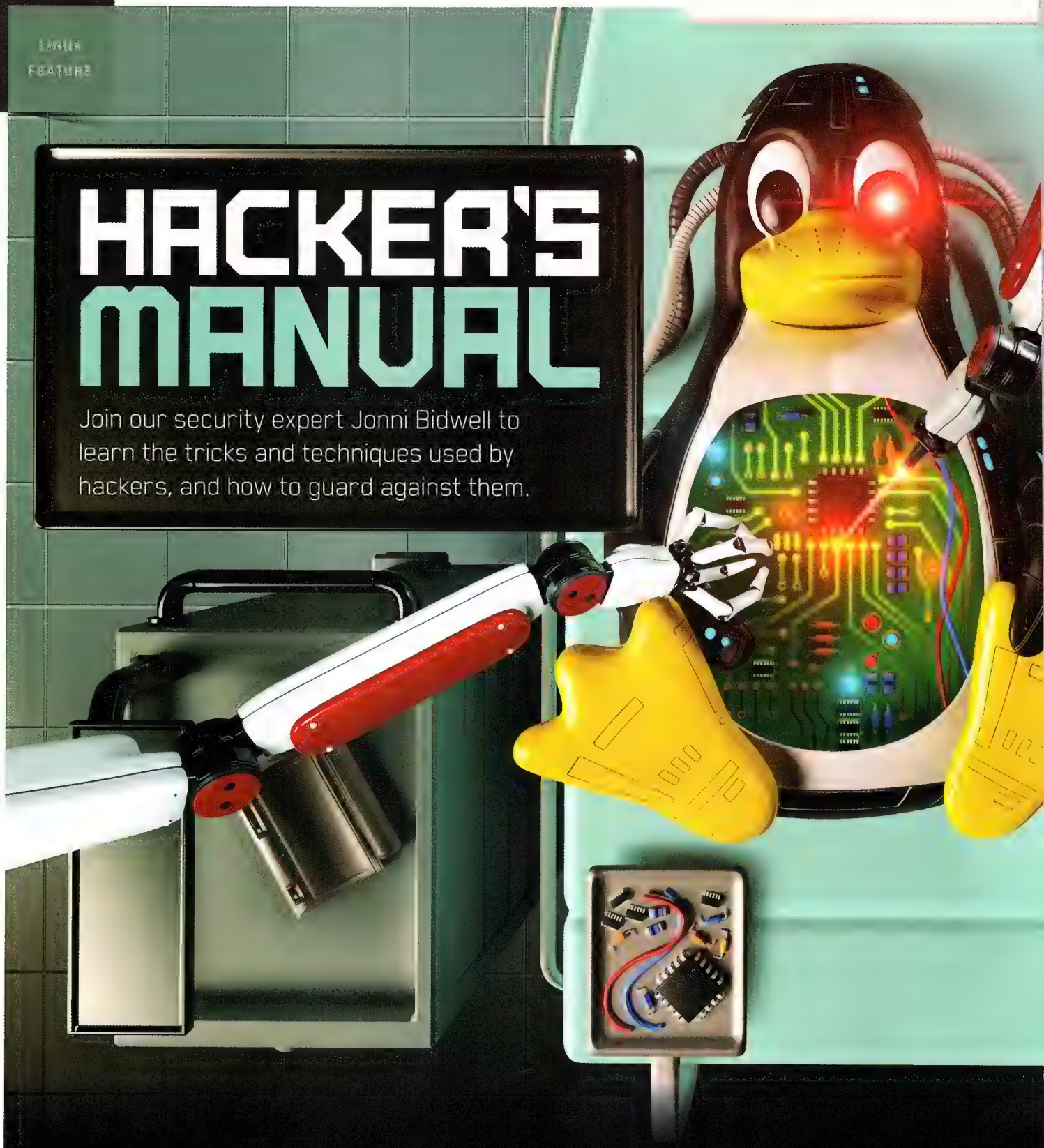
Hopefully you will now feel a little more enlightened about how PCs tick, and especially what's required to get them to boot. ■

The standard Gnome desktop.



Hacker's Manual

Join our security expert Jonni Bidwell to learn the tricks and techniques used by hackers, and how to guard against them.



The 1995 movie *Hackers* has a lot to answer for. Not only was there egregious product placement for a certain fizzy beverage with red and white branding, but it helped reinforce the notion that hacking was all good-looking edgy types breaking into computers and causing havoc.

Today that notion (along with the idea that an oversized black hoodie and *V for Vendetta* mask are essential attire for this hacking) is fairly entrenched among the non-tech savvy, reinforced by unlikely movies and shoddy media reporting.

Readers of this fine publication ought not to buy into that. "Hacking" originally meant the breaking, modifying, and repurposing of technology so that it functions differently to how the manufacturer intended. Today, many programmers call themselves hackers, and only a small fraction of those are up to no good.

Be that as it may, we have been asked to write a feature on hacking, and we're pretty sure they mean the bad kind. But please don't go getting yourself into any trouble. Sure, here we'll show you how to use Kali Linux, Metasploit, and other tools. We'll show you the rudiments of SQL injection, buffer overflows, and other vulnerabilities. We'll even show you how to exploit them. But we won't show you how not to get caught. And if you do get caught, you could face serious charges, so don't do any of this on systems that aren't yours. These tools and techniques are used by legitimate penetration testers to find weaknesses and secure them, and that's why we're sharing them here.

Of course, not everyone is as scrupulous and there are plenty of amateur "how to hack" guides online. So we'll show you how to trick those nefarious hackers and bots with a Raspberry Pi honeypot.

© magictorch/future

HACKING THROUGH THE AGES

From phone lines to fake certificates and social engineers, hacker tradecraft has evolved spectacularly over the years.

People have done bad things with computers for decades. Even before personal computers, people ("phreakers") used to abuse telephone systems. The hacking journal 2600 takes its name from the 2600Hz tone required to trick AT&T phone lines into giving free calls in the 1960s. This was possible because the same line carried both voice and connection-management signals.

Such in-band signalling was done away with in the 70s when a new signalling system was introduced. This enabled different networks to send this data out of band. This system, known as SS7, is still in use today, and is vulnerable to a man-in-the-middle attack. This has been exploited to allow second-factor SMS codes to be intercepted, and accounts to be compromised.

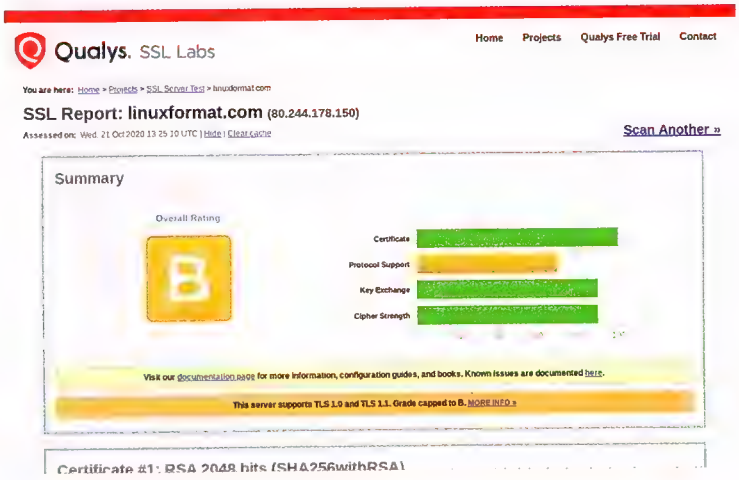
The Morris Worm is widely regarded as the first self-replicating worm to spread over the internet. It was actually a well-intentioned effort to highlight security flaws and count the number of computers on the internet, but an error led to it crippling somewhere between 2,000-6,000 of them (watch Halt and Catch Fire S2 E3). Robert Morris won the dubious honour of being the first person convicted under the Computer Fraud and Abuse Act (CFAA), but post-conviction completed his Ph.D. at Harvard and went on to be a professor at M.I.T.

The worm that turned

The worm exploited a number of vulnerabilities in Unix tools, as well as weak passwords. The problem was re-infection. Morris didn't want his worm to have to ask targets if they were infected and then infect them only if they replied no – this could be stopped by canny sysadmins installing a program that just says yes all the time. So he specified that one-seventh of the time machines would be re-infected. This, it turns out, was high enough that machines quickly ended up running several copies of the worm and became unusable.

Fast-forward to today, and in the headlines we see not only that rogue packages have been hiding in the NPM registry for years and opening shells on JavaScript developers' machines, but also that several Russian individuals have been indicted in the US for attempting to disrupt the 2017 French presidential election, the 2018 Winter Olympics, and Ukraine's power grid. The groups with which these hackers affiliate, it's alleged, all report to Russia's GRU military intelligence unit. It's a little chilling to be reminded that critical infrastructure may be compromised relatively easily.

The Stuxnet worm is widely believed to have been developed by the US and Israel. It was discovered in 2010 targeting Supervisory Control And Data Acquisition (SCADA) systems in Iran, where it's estimated to have crippled one-fifth of their nuclear reactors. The worm was notable because of its ability to attack airgapped (not directly connected to the internet) systems, by exploiting vulnerabilities in how they handled USB devices.


Qualys. SSL Labs
Home
Projects
Qualys Free Trial
Contact
You are here: Home > Projects > SSL Server Test > linuxformat.com
SSL Report: linuxformat.com (80.244.178.150)
Assessed on: Wed, 21 Oct 2020 13:25:10 UTC | Hide | Clear cache
Scan Another »
Summary
Overall Rating
B
Certificate
Protocol Support
Key Exchange
Cipher Strength
Visit our documentation page for more information, configuration guides, and books. Known issues are documented here.
This server supports TLS 1.0 and TLS 1.1. Grade capped to B. MORE INFO »
Certificate #1: RSA 2048 bits (SHA256withRSA)

Even our venerable friends over at **linuxformat.com** have something to learn from this month's feature.

"The Morris Worm is widely regarded as the first self-replicating worm to spread over the internet. It was actually a well-intentioned effort to highlight security flaws and count the number of computers on the internet, but an error led to it crippling somewhere between 2,000-6,000 of them"

WHITE HAT HACKING

There's a school of thought that says we (or anyone) shouldn't provide information that budding hackers could use to cause damage or distress. In February the UK's West Midlands Regional Organized Crime Unit even launched a poster campaign naming and shaming Tor, Kali Linux, and Metasploit, and urging parents to check that their children aren't turning into evil hackers.

But we think differently. By understanding these techniques and having the tools at our disposal to execute them in a responsible way, we can help to create a more secure computing space for everyone.

Penetration-testing is big business nowadays, and companies pay more money than they'd like to admit to have people (red teams) actively try to break into their systems. Meanwhile, blue teams have to do everything within their power to shore up the defences and detect, contain and clean up these intrusions.

There are university-level courses on information security that cover the ins and outs of breaking crypto, return-oriented programming and attacks on the stack. There are even places to learn the ins and outs of social engineering, such is the scale on which it's employed.

© Qualys

INTRODUCING KALI

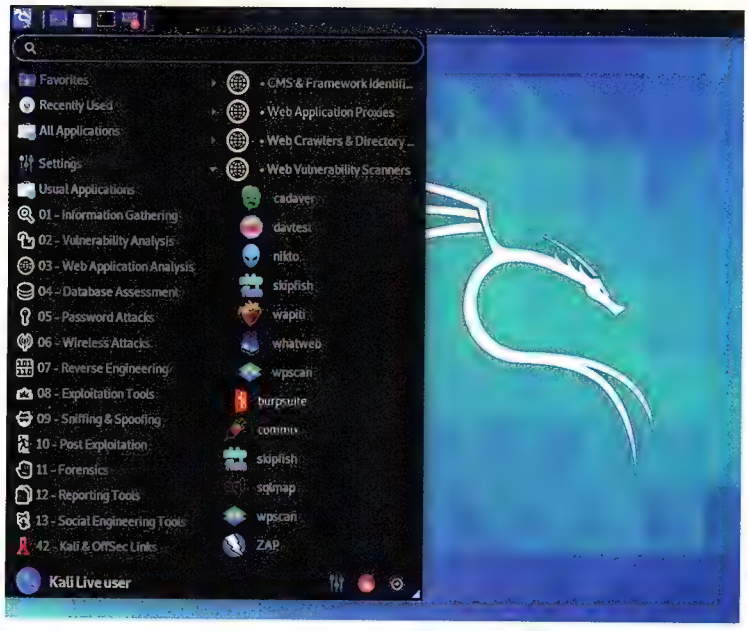
Kali Linux is a powerhouse of pen-testing and security research goodness.

The tools we're going to show you can be installed on pretty much any Linux distro, but we're going to use Kali Linux. This is primarily because it has all these tools installed already, and there's excellent documentation if you want some more information about it.

Kali is probably not something you'd want to use as a daily driver, although if you look online you'll see a lot of posts by budding haxors that do just this. Up until the end of last year Kali used the root account by default, since many tricks such as handcrafting network packets require this. It would be a terrible idea if you were running, say, your mail client as root and you clicked a dodgy link.

Using the root account was sound practice so long as you kept the system "clean" of any of your (or other users') personal affairs. In fact, the risk is often overstated on a single user machine where that user typically has sudo access anyway. However, many applications also require a non-root account, since running them as root presents a security risk.

So now Kali has adapted, and root is no longer the default (the default username and password are both "kali"). However, you still shouldn't use it as a daily driver. You will run into oddities with networking, Bluetooth and package availability, since all these things have been tweaked, either to minimize the attack surface or to make things easier for launching attacks. Perhaps this is why Parrot beats Kali. Parrot is more like a regular distro, with security tools, while Kali is more focused on security and pen-testing. There's no LibreOffice, and because it's based on Debian some repositories are disabled, so installing additional software may not be as easy as you would expect.



Kali Linux is packed with everything you need to start your hacking career.

Launching Kali

You don't even need to install Kali Linux. You can run it from the live environment, either on bare metal or in a virtual machine. So long as you're sure you're using an official Kali image, this will ensure that your other data remains intact – security by separation is good practice, after all. But then again so is keeping your system updated, and it's frustrating to have to do that every time you boot Kali, so an installer is available. It's also possible to create a Kali Live USB stick with persistent storage, which makes life easier if your security business involves gathering data. See **www.kali.org/docs/introduction/download-official-kali-linux-images** to check the image is official. If you find yourself downloading a newer version, be sure to do so from the official website, and follow the checksum and signature-checking instructions.

Kali Linux uses the Xfce desktop – even if you're not familiar with it, it should be easy to navigate. What may be a little overwhelming is the huge amount of stuff packed into the initial install. Fortunately, everything has been categorised in the Applications menu. We don't have enough space to talk about everything, but we can cover the basics, and if you're lucky a couple of more advanced

PORT AUTHORITY

Port scanning is one of the most common first steps towards assessing the security of a particular machine. There are a few ways of doing it, but they all involve attempting to open a connection to various ports on the target machine to see which ones have services running on them (for example, webservers run on TCP ports 80 and 443).

Nmap is one of the most useful port-scanning tools. Fire up a terminal in Kali and run

$ nmap localhost

This will scan the 1,000 most common ports on which services are found. On a default Kali install no services should be running and that command should tell you as much. Nmap by default uses stealth scanning, which only partially opens connections. This makes it harder to detect scans, though a keen-eyed sysadmin poring over a Wireshark packet capture could still spot them. If you run Nmap as root, you'll sometimes obtain a little more info about the target machine and the software it's running. Over the page you'll see how we can use this to find the IP addresses for the many Raspberry Pis on our LAN. Being root also enables you to send raw packets, so there's no need to connect to the target machine. Nmap even has a paranoid stealth mode (which is much slower so as not to trigger detection systems; activate it by adding -T0 to its arguments.

There are other scanners with different purposes. For example Masscan can port scan the whole Internet in about six minutes.

© kali

topics. So fire up Kali, open up a terminal, and carry out some reconnaissance against our own machine, by following the guide in the box (below left).

At this point you can start using some of the tools in the Kali arsenal to probe machines on your network. Or you could run Kali in a VM and then set up another vulnerable virtual machine and start attacking that. VirtualBox's Internal Network option is good for this, as it enables VMs to communicate with one another while isolating them from physical hosts on the network. There are several toy VMs and applications available to practise this on. We'll look at some of these over the page. The most popular is the Metasploitable (a pair of deliberately vulnerable VMs running Windows 2008 and Ubuntu 14.04), which is provided by Rapid7 – the same people who make Metasploit Framework.

Get 'sploiting!

Metasploit Framework is one of the most powerful security tools out there. From its command line interface you have immediate access to thousands of exploit ("sploit") modules, and many more are available from the community. Each module has a variety of parameters, but commonly just a target IP address is required to launch an attack. You'll find Metasploit in Kali's Exploitation Tools menu, or you can start it from the terminal with a simple **msfconsole**. Metasploit features a hierarchy of modules sorted into categories, such as **auxiliary** (things like port scanners and fuzzers), **exploits** (code for exploiting vulnerable systems), and **payloads** (things to execute on a remote machine that's been pwned by an exploit).

There are tools to craft and disguise custom payloads. One of the most useful is a reverse shell, which is like a regular shell, only it connects to you. This is handy if one of your targets is behind a firewall and can't be directly connected to. All an attacker needs to do is make sure a listening service is set up on their machine, and that the service is reachable from the outside. Metasploit has its own Meterpreter shell that can be used for this purpose. All communication with the shell is encrypted, and nothing is written to disk, so it'll be as if you never were there, hypothetically. Not all exploits allow remote code to be executed, but that's not always necessary.

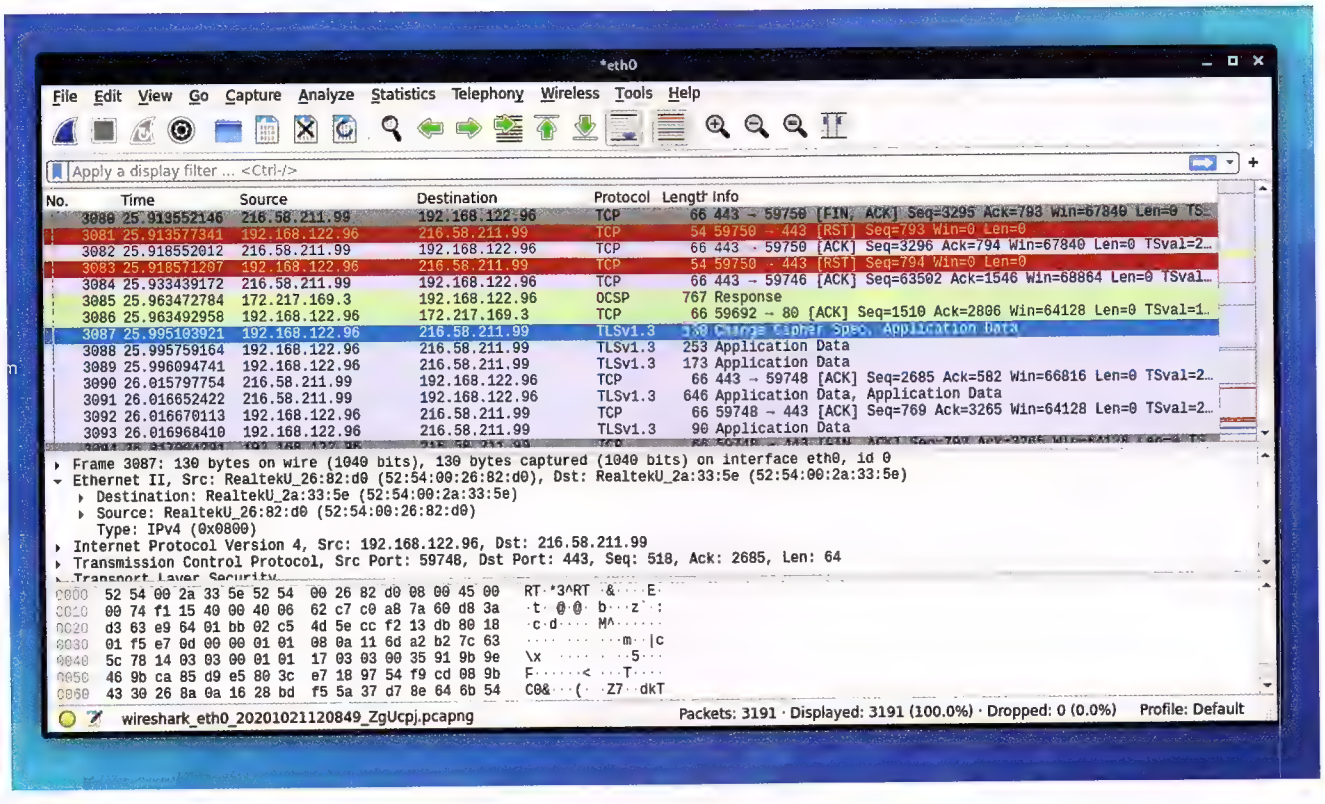
The Heartbleed vulnerability (CVE-2014-0160) was a buffer overflow in OpenSSL that enabled an attacker to read privileged memory and steal passwords, certificates and other private data. Unlike many other bugs, it's easy (with the benefit of hindsight) to spot the mistake in the code. To keep connections alive, the software introduced a "heartbeat" feature, where a client could send a small amount of data to the server, which would echo it back. Unfortunately, it was possible for a client to send a malicious heartbeat request, a single byte long, and request up to 64K back from the server. Because only a single byte was allocated, OpenSSL would read past the end of the buffer and return a random 64K chunk of memory. This may not sound like much, but the attack could be quickly and repeatedly carried out. We may never know if anyone discovered this bug before it was actually announced, but distros quickly patched it afterwards.

To attempt a Heartbleed attack on a server on your network is very easy (it's also easy to do against remote hosts, but don't do that). From Metasploit just do:

```
> use auxiliary/scanner/openssl_heartbeat
> set verbose true
> set RHOSTS 192.168.x.x
> run
```

We hope you're not running a vulnerable version of OpenSSL on your server, but at least this way you'll know.

Heartbleed was notable not just because of its severity, but because it was the first bug to get its own logo, too.



Wireshark enables you to capture network packets straight off the wire, so you can see network traffic in real time.

© heartbleed.com

DISRUPTING DATABASES

Get your first taste of breaking something in the form of a deeply vulnerable web application.

In the past we'd have directed you to hack by setting up the Metasploitable virtual machine and attacking it. We'd encourage you to do that too, (you'll find all the information you need at **https://github.com/rapid7/metasploitable3**). But this time around we're going to do something different. The Damn Vulnerable Web Application (DVWA) is exactly what you might expect: it's a PHP application riddled with security holes. It requires a LAMP (Linux Apache MySQL PHP) stack to run, and it's certainly not the sort of thing you want to deploy on an internet-facing server. So rather than set all that up from scratch, we'll cheat and use the Docker image. Just follow the simple three-step guide (below). We can't get enough of Portainer, so if you're similarly enamoured with this container management solution, by all means use it to do the first step of the step-by-step guide.

Before you do that, though, let's talk about Structured Query Language (SQL). It's how you interact with databases. On Linux this is usually to a MySQL or MariaDB database. Such databases often sit behind web servers running PHP applications (such as Wordpress). And very occasionally those databases or the applications relying on them are broken because someone figures out a way to inject some rogue SQL, often by typing something peculiar-looking into a web form. The classic example is to input something like:

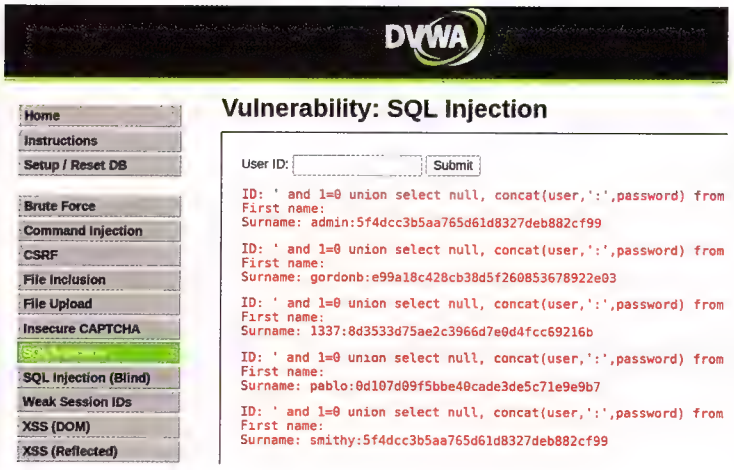
'; DROP TABLE users;

into a form, and have the database suddenly forget about all the users of the application. This generally doesn't work anywhere now, but when it did, it did so because behind the scenes that form sent its input (unchecked!) to a query of the form:

$sql = "SELECT username from users where username = '$user';"

If we substitute our malicious entry above into the $user variable above, and reformat things slightly, our query becomes:

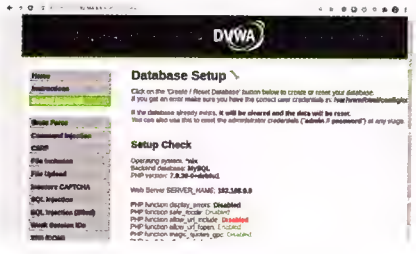
SELECT username from users where username = '';
DROP TABLE users;
';



SQL injection attacks can be devastating. Look – we just made DVWA cough up usernames and password hashes.

"The Damn Vulnerable Web Application (DVWA) is exactly what you might expect: it's a PHP application riddled with security holes. It requires a LAMP (Linux Apache MySQL PHP) stack to run, and it's certainly not the sort of thing you want to deploy on an internet-facing server."

INSTALL THE DVWA IN DOCKER

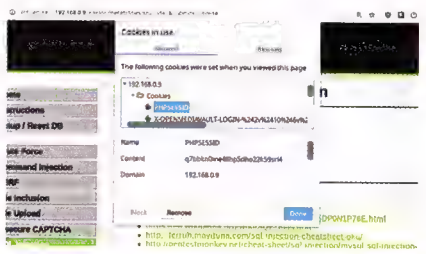


01 RUN THE IMAGE

Use the official instructions to get Docker installed. Then run the image with: **$ docker run –rm -it -p 8080:80 vulnerables/web-dvwa** In a moment you should find the server running on port 8080 of the host machine. Click the "Create/Reset Database" button to begin the fun.

02 BEGIN SLEUTHING

Log in with the super-secure combination **admin:password** and go to the SQL Injection page from the menu on the right. This appears to be some kind of user query utility. Try entering "1" into the form. You should see some information about the admin user. See what else you can find out from here.



03 STEAL A COOKIE

We're going to attack this web app using SQL later on in the tutorial, but to do that we need the session cookie. Click the site information tab to the left of your browser's URL bar and find the cookies the page has set. There should be one called PHPSESSID, which contains a random string of characters. Copy that down.

And you can see why this is bad. SQL injection has been around since the end of the 1990s and continues to plague applications today. This, despite there being no shortage of PHP functions for sanitising input – all the easy attacks stop working if you don't allow punctuation in your forms. Indeed, crudely building SQL statements like this is more or less asking for trouble. Even if the previous example doesn't work anymore (because chaining SQL statements together isn't permitted), there's still all kinds of damage you can do with the UNION operator. So the favoured way to get PHP to talk to SQL nowadays is through prepared statements.

Breaking and entering

Once you've got DVWA up and running you're probably keen to get started breaking it. That's quite easy to do. We'll spoil the fun a little because space is short, but try entering the following doozy into the SQL Injection page:

```
' and 1=0 union select null, concat(user,':',password) from users #
```

As we described above, we've successfully borked the underlying SQL query and tricked the application into coughing up usernames and passwords for the whole team. Oh dear, oh dear. There are some tools that can help find SQL exploits. One of the most popular is sqlmap, which you'll find in Kali's Web Application Analysis menu. In the simplest case, you can probe a form just by passing a URL with something like:

```
$ sqlmap -u http://vulnerable.com/form.php
```

For DVWA, though, because we had to log in to access it we'll need that cookie from step three (below left) if we want sqlmap to see the relevant form. We also need the rather ugly, complete URL from the SQL injection form, which is displayed after you submit it. We'll also cheat a little and turn down DVWA's security via the cookie, otherwise this attack isn't quite so easy. So the proper incantation to sqlmap will look something like:

```
$ sqlmap -u "http://192.168.0.9:9090/vulnerabilities/sqli/?id=bob&Submit=Submit#" --dbs --co
okie="PHPSESSID=q7bbkn0me48hp5dho22k59srl4; security=low"
```

Hit Return if you're told the URL content is not stable – it's nothing to worry about. You can safely skip the tests for non-MySQL payloads and say no to including additional ones. sqlmap will run through its armory of attacks against the `id` parameter and should eventually spit out this helpful message:

```
GET parameter 'id' is 'Generic UNION query (NULL) - 1 to 20 columns' injectable
```

as well as two other injections. After that, it will show you three corresponding queries to exploit these vulnerabilities.

Again, sqlmap is for finding bugs in your own applications. Just because you can point it at any form on the web definitely does not mean you should. We know that many readers will have their own Nextcloud installations (inspired perhaps by our Smart Home Office feature), and we trust that you keep these up to date.

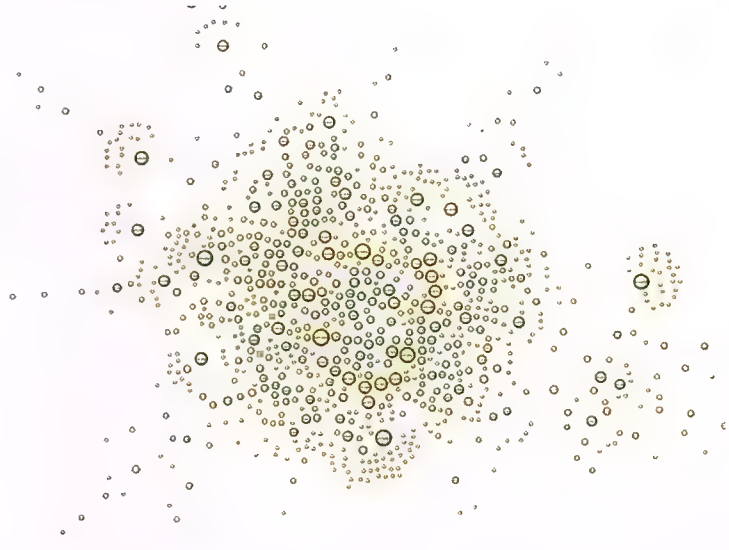
However, just staying updated may not be enough. There's all kinds of room for misconfiguration – not just in Nextcloud itself, but in the underlying LAMP components too. There is some excellent information on hardening your Nextcloud install in the manual, available at **http://bit.ly/MPCnextcloud**, which covers things like giving PHP access to /dev/urandom (to avoid running out of entropy), and SELinux.

There's also a comprehensive security scan you can run from **https://scan.nextcloud.com**, which will make sure your instance is watertight. You'll even get a grade at the end. Any web service you're running should use HTTPS. There's no reason not to now that free certificates are available from Let's Encrypt, as well as its excellent Certbot tool for managing them and keeping them up to date. There's plenty of room for misconfiguring HTTPS too, so go to **https://ssllabs.com/ssltest** and make sure your server gets an A grade.

SOCIAL ENGINEERING

By far the most common attacks involve exploiting human weakness. This might be through a carefully crafted phishing scam, or having a covert agent on the target premises. The compromise of several high-profile Twitter profiles in July was the result of a spear-phishing campaign, where several individuals in the company were targeted until one gave up credentials to account support tools. It wasn't an elegant scheme, but within a few hours followers of the 130 compromised accounts had donated some $150,000 worth of Bitcoin to the scammers. However, they left plenty of tracks and so won't be able to enjoy any of their ill-gotten gains. The mastermind (a teenager from Florida) pleaded guilty to 30 charges in August. Twitter now requires that all employees use physical two-factor authentication (2FA) to access privileged services.

Creating counterfeit banking websites to dupe marks into handing over passwords is a common form of attack. There are plenty of tools for cloning websites, and it's easy to set up a domain name that looks official enough to fool people. Most banks now rely on second factors to log in, but recently cases have been found where the 2FA entry page itself is cloned, so the attacker can relay the credentials to the official page in real time. Always be careful where you click.



Maltego is used to collate data from public sources and find relationships between people, accounts and servers.

DSHIELD PI HONEYPOT

Use a Raspberry Pi to trick hackers into thinking they've found a juicy target, then study them like ants in a jar.

Baiting attackers towards your own hardware might not seem a particularly good idea, but if that hardware has nothing of value on it, and is suitably isolated from your other machines, then you can more or less lure them in with impunity. The goal of setting up a honeypot is not to revenge-hack attackers, but rather to detect attacks, and distract those responsible from more valuable targets.

Opening your home network up to the internet isn't something that should be done lightly, though. If the honeypot machine was to be compromised, then it could be used as a staging post for attacking any services running on your network, including your home router. If you were foolish enough to run a honeypot on your desktop PC, then it's possible that an attacker would gain not only root access it, but to all your files, passwords, browser history, and anything else you use it for.

DShield is an easy-to-use honeypot that can be installed anywhere. The Raspberry Pi is ideal for this because it's cheap and the SD card can easily be wiped if something goes wrong. DShield is a distributed intrusion-detection system created by the Internet Storm Center (ISC). In its own words, "DShield collects data about malicious activity from across the internet. This data is catalogued and summarised and can be used to discover trends in activity, confirm widespread attacks, or assist in preparing better firewall rules." So setting up a Pi-based DShield sensor, as they're termed, will help the security of the internet in some small way. DShield uses Cowrie, which runs dummy SSH, web, and other services to tempt attackers and gather data about what they're trying to do.

Get started with DShield

Before you can use it you'll need to join the project by setting up an account at **https://dshield.org**. DShield can be installed on any Linux distribution via Git, and some tweaks are necessary to install it on the Pi. Check the project's Github at **https://github.com/DShield-ISC/dshield** if our instructions here fail you. Before we get to DShield, though, we need to ensure that our Pi is correctly set-up. We'd recommend starting with a fresh installation of Raspberry Pi OS Lite. If you don't have a monitor and keyboard for your Pi to hand, then you can activate the SSH server and interact with it that way by placing an empty file called ssh on the SD card's boot partition:

```
$ touch /media/user/boot/ssh
```

After that, you can use Nmap to help you find the Pi's IP address on your local network with something like:

```
$ sudo nmap -p22 –open 192.168.0.*
```

which will search the network for devices running on the default SSH port. Your Pi should be easy to spot because it'll show up as a Raspberry Pi Foundation device. Log in (either by SSH or physically) using the default pi:raspberry credentials.

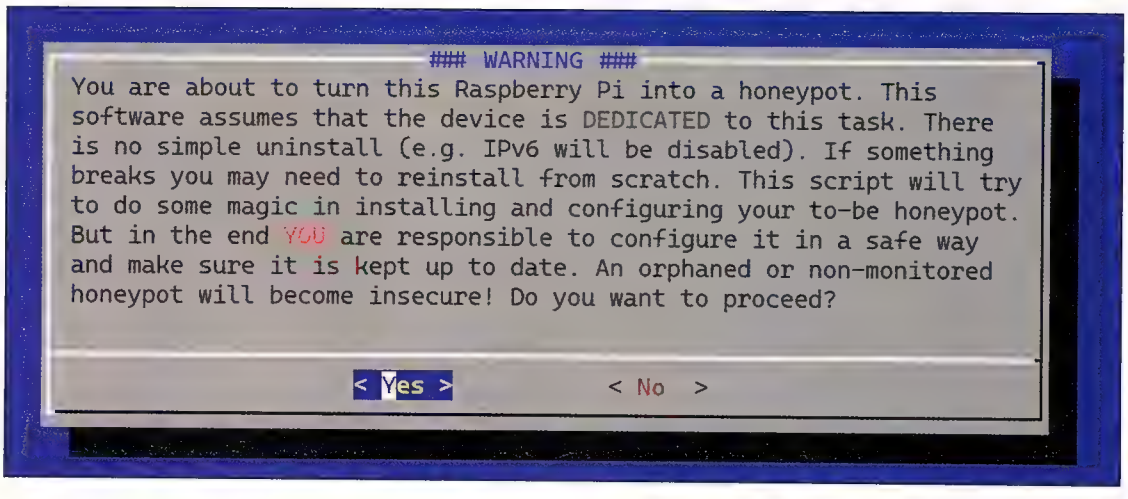
Ensure the date is set correctly by running:

```
$ date
```

If it isn't, then you'll end up generating invalid SSL certificates, and various other things will fail mysteriously. It's also worth running `raspi-config` for the purposes of changing the default password, making SSH permanently active, ensuring the correct timezone is set, and expanding the filesystem to use the entire SD card. Before you reboot, it's worth upgrading everything (which will take some time so a cup of coffee is recommended), and installing Git.

```
$ sudo apt update
$ sudo apt upgrade
$ sudo apt install git
$ sudo reboot
```

"If the honeypot machine was to be compromised, then it could be used as a staging post for attacking any services running on your network, including your home router."


WARNING
You are about to turn this Raspberry Pi into a honeypot. This software assumes that the device is DEDICATED to this task. There is no simple uninstall (e.g. IPv6 will be disabled). If something breaks you may need to reinstall from scratch. This script will try to do some magic in installing and configuring your to-be honeypot. But in the end YOU are responsible to configure it in a safe way and make sure it is kept up to date. An orphaned or non-monitored honeypot will become insecure! Do you want to proceed?
< Yes >
< No >

Please do heed this warning and understand the horrors that your Pi may be exposed to in the DMZ.

Reconnect to your Pi and clone the DShield repository:

```
$ git clone https://github.com/DShield-ISC/dshield.git
```

Then run the installation script:

```
$ cd dshield/bin
$ sudo ./install.sh
```

The script will install lots of packages (you probably have time for another cup of coffee during this phase) and then give you one last chance to bail out. Do heed this warning: if you proceed it will ask you for your email address and API key, which you set up earlier. The key is in the My Account section on the website. Next, you'll be asked for a network interface (wired is recommended) and which networks and IPs to trust. It figures these out based on machines currently connected to the Pi. As part of the bait, a bogus SSH instance will take over the default port, so after this step you'll need to SSH to port 12222 to administer DShield. Finally, some Python packages will be installed via Pip, and a certificate will be generated (it's okay to accept all the defaults here). And by now you've definitely earned that third cup of coffee.

Reboot the Pi again and SSH to the new admin port, and check all is well with DShield:

```
$ ssh -p 12222 pi@192.168.x.x
$ cd dshield/bin
$ sudo ./status.sh
```

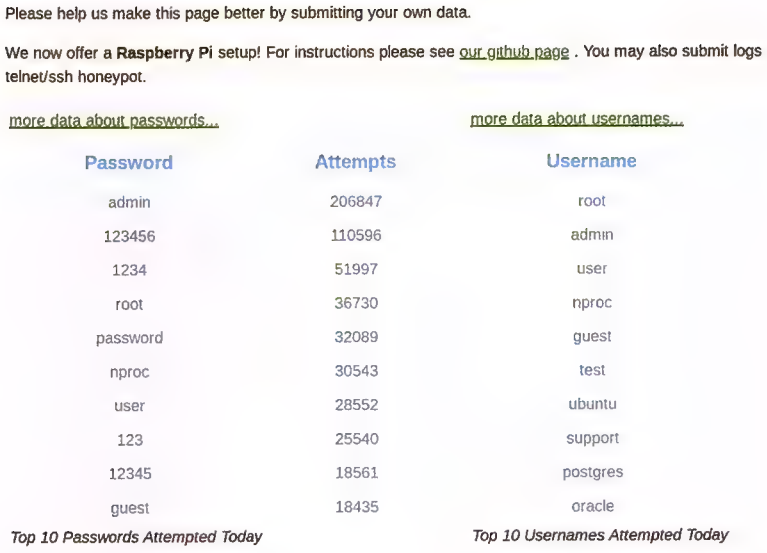
You should see an error saying that the webserver is not exposed. To attract bots and humans from outside your network, you need to tell your home router to forward incoming connection attempts to the Pi. You may already have some forwarded ports set up, either manually or via uPNP. Each router is different, but most have a DMZ (demilitarised zone) option, which will forward all traffic that wouldn't be forwarded elsewhere. You could also forward only selected ports, but the goal of DShield is to capture as much traffic as possible, so this isn't really recommended.

To see connection attempts in real time, run:

```
$ tail -f /var/log/dshield.log
```

Follow the action

Besides logging usernames and passwords for any attempts to login, Cowrie – another honeypot – will also fake a command shell to several common usernames and passwords and capture the whole session. Any URLs requested from the webserver are also collected. Follow Cowrie activity with:



Please help us make this page better by submitting your own data.

We now offer a **Raspberry Pi** setup! For instructions please see our github page . You may also submit logs telnet/ssh honeypot.

more data about passwords...

Password	Attempts
admin	206847
123456	110596
1234	51997
root	36730
password	32089
nproc	30543
user	28552
123	25540
12345	18561
guest	18435

Top 10 Passwords Attempted Today

more data about usernames...

Username
root
admin
user
nproc
guest
test
ubuntu
support
postgres
oracle

Top 10 Usernames Attempted Today

```
$ tail -f /srv/cowrie/var/log/cowrie/cowrie.log
```

If you want to play around in Cowrie's faux shell, just SSH to your router's external IP address (Cowrie doesn't listen on the internal address) using the credentials `root:password` . Lots of standard shell commands will appear to work correctly, but if you try something like `rm -rf` on the root directory you'll quickly see that it's all trickery. Everything you type is logged, and you can `grep` it out of the logs (after first logging out of Cowrie's deceptive shell) with:

```
$ grep CMD /sr v/cowrie/var/log/cowrie/cowrie.log
```

It's important to not take these personally, and remember that most of these will be automated scans and bots. DShield is configured to send logs every half hour via a cron job. After that time your data will be visible from the My Account menu at the DShield portal.

Cowrie is designed to mimic services, but also to be very simple behind the scenes. This reduces the possibility of it actually falling to a vulnerability at some stage. After a few hours' use, our logs started to show a few Python tracebacks resulting from Cowrie crashing out. This is in general nothing to worry about. In theory that's not meant to happen, and those tracebacks are sent to the project to stop them happening in future. ■

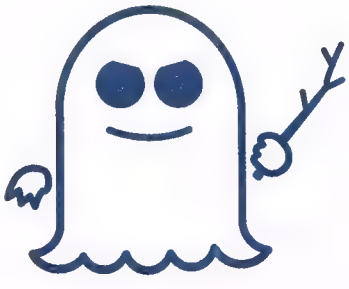
After a few days spent using DShield, you'll see how unimaginative the bots are with their feeble password attempts.

ROOTED ROUTERS AND PRUDENT USERS

Most of what we've covered here will be more of interest to those wanting to defend their services than to home users. It's hard to give general advice for protecting your home network. We've always told users to keep their software updated and to be wary of emails from princes needing somewhere to stash their fortunes. And in general that advice goes a long way – those princes aren't real, and popular applications are patched quickly. The Linux kernel has second-to-none security processes, even in the face of Spectre and Meltdown vulnerabilities that will be here for a long time.

We put a lot of trust in our home routers, though, and perhaps that's misplaced. Imagine if all the machines on your network were subject to the same probing and bothering that our honeypot endured over the past few days.

In 2018 a strain of malware dubbed VPNFilter was found to have infected half a million home routers worldwide. While no damage was ever recorded from this attack, the malware had the ability to siphon off traffic, collect personal information, or brick the host router entirely. A domain used as a command and control (CnC) server was seized by the FBI soon after it was discovered, paralysing it. As IPv6 gains adoption, and as more IoT devices are exposed to the internet without appropriate security, this kind of attack will become more prevalent.



Speculative execution bugs are going to haunt us for years to come. WoooHOOO!

© DShield

PC BUILDER

WHAT'S HAPPENING IN THE AUSTRALIAN PC MARKET

System news

AMD woke the sleeping dragon with Ryzen, now Mark Williams watches as Intel begins to flex its muscles.

MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

Intel has been on the back foot ever since AMD launched its first-generation Ryzen processor in 2017, sporting a new chiplet design strategy. Intel, it seemed, didn't initially think it was much of a threat, but with each new Ryzen generation it watched AMD eat away at its long-held performance lead. Until finally when the Ryzen 5000 series launched and took the performance crown from Intel outright in all categories, even in its last stronghold of gaming performance. This combined with Apple's decision to ditch Intel in favour of its own in-house designed ARM-based processors meant that Intel's confidence had all but been defeated.

Back in January Intel appointed a new CEO, Pat Gelsinger a former long-time star employee to help steer Intel in a new direction and revive the company's fortunes. Two months later and Gelsinger has stirred up much excitement amongst employees and launched a humorous ad campaign poking fun at Apple products using none other than Justin Long, the 'Mac' from the famous 'I'm a Mac' TV ads from the early 2000s. It's obvious Intel is not happy that Apple cut it loose.

Gelsinger – having re-invigorated the company – recently announced its new strategy going forward.

Digging into the topics, Gelsinger spoke about its 7nm process progress, essentially saying that after fixing the blockages in the pipeline it is on track to make its debut in 2023 with Meteor Lake, a processor that appears to be Intel's full response to Ryzen in that it'll be a chiplet (or "tile" as Intel likes to call them) system-on-package design leveraging multiple manufacturing nodes, processes and packaging techniques like Foveros and EMIB to build.

While exciting to hear, that's still a solid two years away, by which time TSMC is expected to be in volume production of its 3nm node. On the surface it still seems like Intel might be a tad behind the leading edge, but with 12th Gen Alder Lake processors coming later this year and finally shipping 10nm parts to the desktop, it seems like Intel is once again on the move with manufacturing.

On the topic of manufacturing, Gelsinger also announced a major shift in Intel's posture with regards to its crown jewels – its fabrication plants. Long held as its prized possession that no one else could use, Gelsinger announced that Intel's new IDM 2.0 (Integrated Device Manufacturing) strategy would result in Intel using more third-party foundry capacity than it does today for the manufacturing of its new compute tiles, giving it the flexibility on price, power and capacity that it needs going forward.

Gelsinger also announced that Intel would be building two new fabs in Arizona USA, solely dedicated to giving guaranteed wafer capacity for its next and biggest announcement – Intel becoming a world-class foundry business. This means Intel will open its doors to customers wanting to have chips fabricated and using Intel's fabs to do it. Essentially, Intel will start competing more directly with the likes of TSMC, Samsung and Global Foundries to produce semiconductors for the global economy. This announcement will be music to Joe Biden's ears, having declared he wanted to help fix the global chip shortage. Intel is committing to building more fabs in the US and EU to diversify supply away from Asia which currently holds around 80 percent of the global semiconductor supply chain.

Building more fabs around the world and opening its doors to customers will be a boon for global chip supply and help solve the shortage in which we currently find ourselves. Not to mention give some of the larger economies around the world sovereign control over semiconductor supplies.

Exciting times ahead at Intel. For now, at least, we know that 10nm is the best we'll see for Intel's processors until 2023 rolls around. Let the fabs wars begin!

Intel's new CEO Pat Gelsinger is a man with a big mission.

Shop talk

How are you currently finding the supply of Intel CPUs?

RICHARD, AFTERSHOCK PC:

"We have found supply of Intel CPUs to be pretty good lately. However, we sell a lot of the higher end units and have had a bit of trouble getting the 10900KF over the past month, but have mostly been able to get the stock we need.

So far from what I can tell, the 11th Gen looks like it will be in fairly good supply for the launch so let's hope that is the case. We have definitely seen an increased uptake of Intel products due partly to supply but also their price drop not long ago which has made their mid to higher end units very competitive against AMD." ■

Market snapshot

An overview of typical systems in today's market.

$1,899 | tinyurl.com/APC493JWC

JW Computers GMR TUF 1660

It is a sign of the times when something as entry level as this system is approaching two thousand dollars. The global silicon shortages are making it tough to stick to pre-COVID pricing, this system however is still around two hundred dollars overpriced. Similar builds from other system builders can be had for less. So, shop around if looking for a similar grade of PC. Having said that, the quad core CPU will be enough for most general tasks. Playing eSport games should be ok too, but it will struggle with more recent CPU heavy titles and will end up being a bottleneck for the GPU longer term. The B450 chipset will keep your options wide open for future drop in CPU upgrades though and helps to keep the price down. A good starting point for eSports fans.

CPU: AMD Ryzen 5 3500X **Cooler:** Cooler Master Masterliquid ML120R RGB **Motherboard:** Asus B450 Chipset **Graphics:** GeForce GTX 1660 Super **Memory:** 16GB DDR4 3200MHz **Storage:** WD Black 500GB **Power Supply:** 550W **Case:** Asus GT301 TUF RGB.

$2,449 | tinyurl.com/APC493SCP

Scorptec Phantom RTX 3070

Ah, the sweet spot. Not too much of an asking price and just enough performance to play everything. This system sports the venerable and still quite capable Ryzen 5 3600. A respectable gaming CPU, though it has recently come to light that Nvidia graphics card drivers can bottleneck at 1080p on slower CPUs, including this one. It's not by a large enough margin to worry about too much. However, if you're planning to play at 1440p or higher the problem disappears. The B450 motherboard will give you the capability of moving up to a Ryzen 5000 series processor later which could be handy. The graphics card is well suited to 1440p and ultra-wide monitor resolutions at above 100Hz frame rates. It is good all-around this system.

CPU: AMD Ryzen 5 3600 **Cooler:** OEM **Motherboard:** Gigabyte B450M S2H **Graphics:** Zotac Twin Edge GeForce RTX 3070 OC 8GB **Memory:** Corsair Vengeance LPX 16GB 3200MHz DDR4 **Storage:** Western Digital WD Blue SN550 500GB M.2 SSD, Seagate BarraCuda 2TB HDD **Power Supply:** SilverStone Strider 650W **Case:** Antec Dark Phantom DP301M.

$6,253 | tinyurl.com/APC493PLE

PLE Computers Gen 11 Valiant

One of the first pre-builts on sale featuring a new Intel 11th Gen CPU. If you're an Intel fan and are wanting Intel's latest and greatest this system is certainly a place to start. However, going off early 11th Gen benchmarks it appears to not be that great of an upgrade over 10th Gen parts, let alone a Zen3-powered system by AMD. Combined with the hefty price the i9 commands over the almost similarly performant 11700K, this system doesn't exactly represent good value at the moment. The rest of the system is rather nice with Samsung's new PCIe Gen4 enabled SSD included and the best graphics card available this system won't leave you wanting for much. With no clear CPU upgrade paths to speak of and stagnant CPU performance gains, think carefully before deciding on this pricey system.

CPU: Intel Core i9 11900K **Cooler:** ID-Cooling ZoomFlow 360X RGB AIO **Motherboard:** Gigabyte Z590 Aorus Pro AX **Graphics:** Gigabyte GeForce RTX 3090 Gaming OC 24GB **Memory:** Thermaltake 16GB DDR4 ToughRAM Z-One RGB C18 3600MHz **Storage:** Samsung 980 Pro 500GB, WD Blue WD20EZAZ 3.5" 2TB **Power Supply:** Thermaltake Toughpower Grand RGB 850W **Case:** Thermaltake S300.

$7,499 | tinyurl.com/APC493AFT

Aftershock PC Asus TUF White Extreme Edition

With so much compute power under the hood in this beastly system, you need to be sure you're capable of fully utilising it all, as it doesn't make a whole lot of sense if all your going to be doing is gaming. The sixteen core CPU powering this monster will be left mostly idle during gaming and will be better utilised in creative or more professional tasks. Sporting a rare as hens' teeth RTX 3080 is quite an achievement, though given the productivity bent of this system it's a wonder an RTX 3090 isn't used instead for its extra VRAM. The storage is quite noteworthy too, again pointing to the heavy compute tasks. A powerful system for those that can properly leverage it.

CPU: AMD Ryzen 9 5950X **Cooler:** Asus ROG Strix 240mm AIO (White) **Motherboard:** Asus ROG X570 Crosshair VIII Dark Hero (WIFI) **Graphics:** Asus ROG Strix RTX 3080 (White) **Memory:** 32GB DDR4 G.Skill Trident Z Neo RGB 3600MHz **Storage:** 2TB Gen4 M.2 SSD, 2TB Gen4 M.2 SSD, Tertiary Drive: 8TB HDD **Power Supply:** Asus ROG Strix 850W **Case:** Asus TUF GT501 (White).

BLUEPRINTS

VALUE- AND PERFORMANCE-DRIVEN HYPOTHETICAL BUILDS

PC BUILDER

Budget

Competent.

We're starting to dread putting these build lists together, especially when it comes to the GPU situation. So let's address that first and foremost. We wrote this piece over a period of 24 hours. Two working days. In that time, the GPU we picked for the AMD build went out of stock overnight, and the GPU we had from last issue for the Intel build skyrocketed in price. The closest available graphics card, the four-and-a-half-year-old GTX 1050 Ti that's actually in stock, is now $250.

We don't know what to tell you. Right now, if you're building these systems, you just have to be on your toes and hope you can pick up a GPU at a reasonable price when it's available. Between the crypto-boom, the miners, the scalpers, and ordinary folk just trying to buy a damn graphics card, the likelihood of actually being able to get one of anything is near impossible. Fortunately both systems here are configured with integrated graphics as standard, so if you desperately need a rig, you can pick one of these up and run it through integrated, much like our feature build this issue.

Aside from that, we've swapped out our power supply in the AMD build for our Corsair pick from this month's main build (as the EVGA BR is now the same price), and plumped up for some slightly better spec memory. On top of that we've swapped back to the Core i3-10100 for the Intel setup (integrated graphics, and slightly more affordable), and managed to pick up this dirt-cheap mobo from Asus, to shave off a bit of price from the last issue.

So technically each build has saved around $245 for the AMD build compared to last issue, and $120 for the Intel PC – theoretically true if you can get that 1050 Ti at $250. Technically we've gone down from a ridiculously overpriced GTX 1660 at $370 (last issue, now $450-500 of course) to a 1050 Ti at $250. But as neither of the cards are easily found, really the true street prices of these builds are variable, and undoubtedly higher than what we're printing today.

AMD INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	450W CORSAIR CV450 80+ BRONZE **NEW**	$50
M/BOARD	ASROCK B450M-HDV R4.0 M-ATX	$100
CPU	AMD ATHLON 3000G	$95
GPU	MSI GEFORCE GTX 1050 TI 4GB GAMING X	$250
RAM	16GB (2X8GB) TEAM T-FORCE VULCAN Z @ 3000 MHZ **NEW**	$110
SSD	250GB SAMSUNG 980 PRO M.2 PCIE 4.0 SSD	$110
HDD	1TB SEAGATE BARRACUDA 1TB 7200 HDD	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		$905

INTEL INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	450W EVGA 450 BR 80+ BRONZE	$50
M/BOARD	ASUS PRIME B460M-A MICRO-ATX **NEW**	$140
CPU	INTEL CORE I3-10100 **NEW**	$170
GPU	MSI GEFORCE GTX 1050 TI 4GB GAMING X	$250
RAM	16GB (2X8GB) TEAM T-FORCE VULCAN Z @ 3000 MHZ **NEW**	$110
SSD	500GB SAMSUNG 970 EVO M.2 PCIE 3.0 SSD	$110
HDD	1TB SEAGATE BARRACUDA 1TB 7200 HDD	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		$1,075

PC BUILDER

Mid-range

Decent.

Oh we so want to change the record at this point, but this is just getting worse, month on month. On the flip-side, we are starting to wonder whether graphics cards might actually be a better investment than cryptocurrency. That RTX 2060 Super we recommended last issue – you know, the card that launched early 2019 – has gone up by another $50. Not a fatal blow, but a sign of the times.

Aside from that, we have managed to make a few changes. Interestingly, AMD still has zero or almost zero stock of its latest chips, so we're relying on the Ryzen 5 3600 as our processor of choice at $300. Intel, on the other hand, seems to be doing just fine, and we've got a bit of budget room to go for the overclockable Intel Core i7-10700K for $500. It's genuinely frustrating because the latest Ryzen processors are incredible, but it's so hard to find stock.

On top of that we've had to swap the motherboard in the Intel rig. It seems that prices across the segment have gone up, so we've picked up the Z490 Pro4 from Asrock at $220. We've also had to downgrade the AMD memory to a 3,200MHz kit, and even with that drop we're still looking at a price increase of $5. We've also switched out the coolers to two slightly more affordable Cooler Master variants – both 240mm, of course. It's worth pointing out that a lot of these parts are interchangeable across the two builds– the storage, power supplies, and cooling in particular, although we'd recommend staying away from 2,400MHz memory for your Ryzen processors, as always.

That said, despite all the bad and sad news, both rigs have managed to come down in price by $300-500 compared to last issue, in no small part because we've "swapped" from the $700 to $800 GPUs from last issue's mid-range builds, to the much more "affordable" $420 GTX 1660 this issue. Oh please let this end.

AMD INGREDIENTS

PART		PRICE
CASE	LIAN LI PC011-DYNAMIC	$200
PSU	550W CORSAIR RMX (2018) 80+ GOLD	$130
M/BOARD	ASROCK X570 PHANTOM GAMING 4 **NEW**	$200
CPU	AMD RYZEN 5 3600	$300
COOLER	COOLER MASTER MASTERLIQUID ML240L RGB V2 **NEW**	$100
GPU	EVGA GEFORCE GTX 1660 SUPER SC ULTRA GAMING **NEW**	$420
RAM	16GB (2 X 8GB) CORSAIR VENGEANCE LPX DDR4 @ 3200 **NEW**	$130
SSD	500GB SABRENT ROCKET 4.0 M.2 PCIE 4.0	$150
HDD	1TB SEAGATE BARRACUDA 1TB 7200 HDD	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$1,745**

INTEL INGREDIENTS

PART		PRICE
CASE	LIAN LI PC011-DYNAMIC	$200
PSU	650W EVGA G5 80+ GOLD **NEW**	$170
M/BOARD	ASROCK Z490 PRO4 **NEW**	$220
CPU	INTEL CORE I7-10700K **NEW**	$500
COOLER	COOLER MASTER MASTERLIQUID LITE 240 **NEW**	$100
GPU	EVGA GEFORCE GTX 1660 SUPER SC ULTRA GAMING **NEW**	$420
RAM	16GB (2 X 8GB) G.SKILL AEGIS 16GB @ 2400	$105
SSD	500GB WD BLACK SN750 M.2 PCIE 3.0	$110
HDD	1TB WESTERN DIGITAL CAVIAR BLUE 7200	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$1,940**

PC BUILDER

Turbo

Stupendous.

Let's start with the good news first: both processors have fallen in price, or not increased! Huzzah! The Ryzen 7 5800X is down by $70 to $730 (its actual RRP), though the Intel Core i9-10900K has held steady. That's a little bit of good news, but it does put us in a bit of an odd position, given how close the pricing is on that, because if you want a chip for purely multi-threaded applications, the Core i9-10900K is the more affordable bet (nipping past the 5800X by around five percent in benchmarks). However, if gaming and single-core performance is more your thing then the 5800X is the chip to get, as it outmuscles the 10900K by an impressive 20 percent in those applications (Cinebench R20 being used as our comparison here, so your mileage may vary based on application).

To celebrate those price drops we've opted for better motherboards, with slicker design aesthetics and better rear I/O. We've done some maneuvering for the power supplies too.

We're sticking with the same HyperX memory from last month as it's very well priced relative to other premium brands, and it does look a treat, we must say.

So, the elephant in the room – still no graphics cards in stock at this price point. You could wait on availability for one of these blower-style RTX 2080 Supers, for the low, low price of $1,400. Sadly, even on the cheapest end that's a price increase of around $150 compared to last issue. But on the plus side you can always run that Core i9-10900K system on integrated graphics, right guys? Right?! (sorry AMD, you miss out on that luxury).

Is there an end in sight to all of this? Well, not for now. If you really want to game, game streaming is a more affordable solution. If you need a GPU for anything else, however, your choices are limited.

AMD INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$220
PSU	750W BE QUIET! PURE POWER 11 80+ GOLD **NEW**	$200
M/BOARD	GIGABYTE X570 GAMING X ATX **NEW**	$210
CPU	AMD RYZEN 7 5800X	$730
COOLER	CORSAIR ICUE H150I ELITE CAPELLIX 360MM AIO	$300
GPU	ASUS GEFORCE RTX 2080 SUPER 8GB STRIX GAMING **NEW**	$1,400
RAM	32GB (2 X 16GB) HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ	$240
SSD	1TB SABRENT ROCKET 4.0 M.2 PCIE 4.0 **NEW**	$300
HDD	6TB WESTERN DIGITAL BLUE	$260
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$3,920**

INTEL INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$220
PSU	750W SEASONIC FOCUS PLUS GOLD 80+ GOLD **NEW**	$195
M/BOARD	MSI MAG Z490 TOMAHAWK ATX **NEW**	$300
CPU	INTEL CORE I9-10900K	$780
COOLER	NZXT KRAKEN X73 360MM	$300
GPU	ASUS GEFORCE RTX 2080 SUPER 8GB STRIX GAMING **NEW**	$1,400
RAM	32GB (2 X 16GB) HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ	$240
SSD	1TB CORSAIR MP400 M.2 PCIE 3.0	$195
HDD	6TB WESTERN DIGITAL BLUE HDD	$260
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$3,950**

GIGABYTE™

GIGABYTE M27Q

WORLD 1ST KVM GAMING MONITOR

KVM

TYPE-C

AORUS ANZ WEB

AORUS ANZ Instagram

Suggested price is **$499** (GST INC.)

BUILD IT

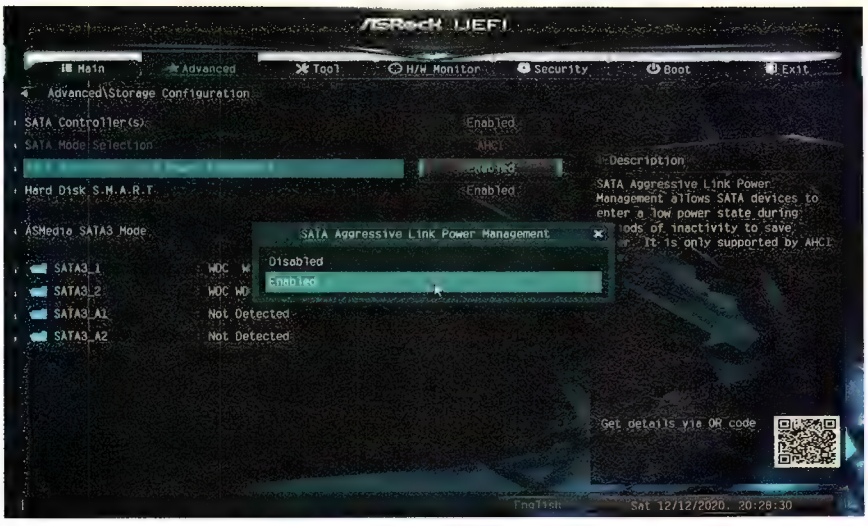
Set up your own NAS server

Nick Peers reveals how to build and set up your own custom NAS-beating server.

Why would you want to build your own NAS server? You can easily pick up a decent off-the-shelf model in the form of a QNAP or Synology NAS, complete with its own operating system, range of apps and all the rest. Why? Because you're an *APC* reader, do you need any other reason?

Of course not, but we'll give you some anyway. QNAP and Synology are very good at what they do, but you're tied into their ecosystems, which limits you to their choice of hardware, software, and even proprietary filesystems. None of this sits well with us, particularly when our TS-251+ proved so poor at hardware transcoding.

The beauty of the self-build system is that you're in complete control, from choosing the components that make up your turbo-powered NAS, to selecting which operating system powers it. We've hand-picked the best components for a low-powered NAS build, but you're free to use whatever you want– an old PC or laptop will do nicely, or even set one up inside a virtual machine. Our NAS will run Ubuntu Server for maximum flexibility and performance, designed to run headless while remaining accessible and easy to manage via any PC on your local network with a web browser. Ready to get started?



Scour the BIOS for power-efficiency tweaks like this.

First, what hardware will your NAS server be based on? Any PC capable of running Linux is the simple answer. You might have an old PC or laptop gathering dust somewhere looking for a new purpose in life, or perhaps you're looking for an excuse for your next build. The box on the opposite page reveals what we based our server on, which we found very easy to build.

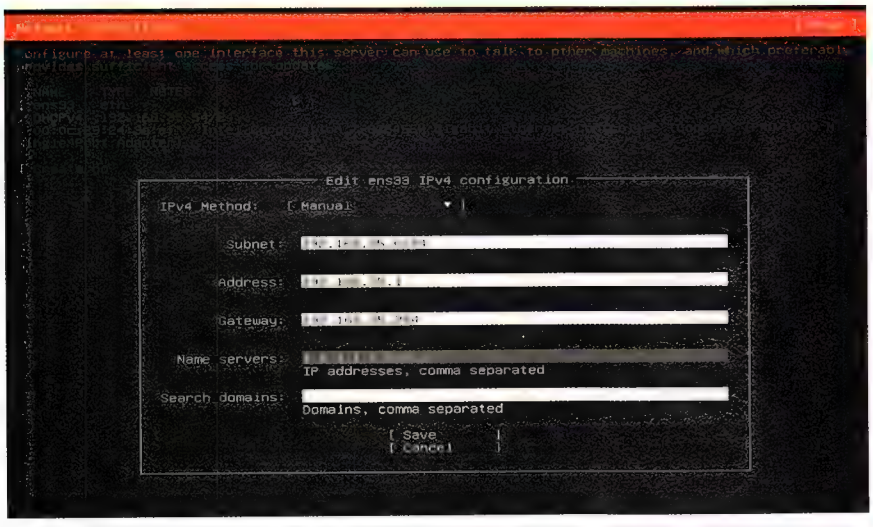
Your NAS server needs a suitable operating system to run, and because it's designed to be run headless, we're going to install Ubuntu Server 20.04 LTS. The Server version doesn't come with unnecessary overheads, including a desktop – everything is done from the command line. Don't worry, though: after it's been set up, we'll install a special add-on (Cockpit) that enables you to easily administer your server remotely from any web browser on your local network. We chose the LTS version to reduce the number of major OS upgrades we'll need to apply during the server's lifetime.

So, once your server's set up and running, you won't need to leave it permanently connected to a monitor or keyboard. That said, it's useful to have access to both resources in case your server loses its network connection. For example, we've got our server tucked away beneath our feet, connected to our main PC's monitor and with the front USB ports easily accessible, should we need to plug in a keyboard.

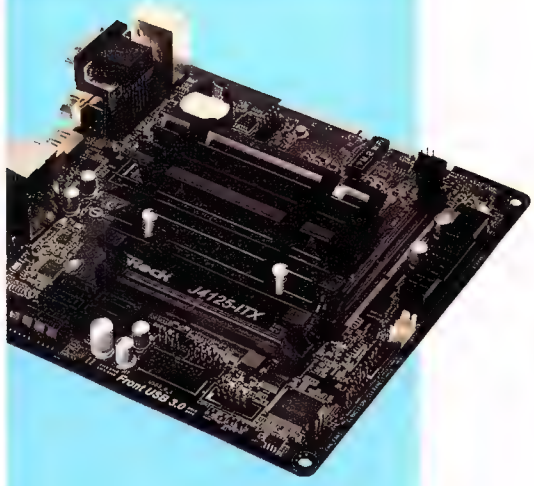
Start the install process

Head to **www.ubuntu.com/download**

"The beauty of the self-build system is that you're in complete control, from choosing the components that make up your turbo-powered NAS, to selecting which operating system powers it."



Ubuntu Server's text-based install wizard is simple enough.



Build your own NAS

If you're looking to build your own NAS from scratch, then there are two key considerations: chassis size, and power draw. A NAS is designed to be run 24-7, so a low-powered CPU like Intel's Atom range seems a logical choice. But if you want to use your NAS as a Plex or Jellyfin media server, you need a processor with decent hardware transcoding support. This is where Intel's Pentium Silver J5040 chip comes into its own: quad-core, with onboard Intel UDH Graphic 605 ensures that the hardware transcoding produces watchable streams, while its miniscule power draw means the chip can be cooled by heatsink alone.

Our server was built around the Asrock J5040-ITX motherboard (pictured above), which comes with the J5040 chip onboard with heatsink. It technically supports up to 8GB RAM, but we successfully installed 16GB, and comes with four SATA ports, one PCIe slot (to which we added a further two SATA ports), and plenty of USB connectors too. We paired this with an InWin IW-MS04 server case ($250) – it has four removable drive bays, plus two internal drive slots, and we placed our 1TB WD Red SSD drive into one of these for running the OS and key services. We then populated two of the four drive bays with existing 6TB and 3TB WD Red drives, which is where our data files – including media collection – is stored.

The build was relatively simple, and we'll be showcasing this in a future issue.

Snaps *vs* repos

Traditionally, software is installed on Ubuntu via package archives known as repositories, and these remain a vital tool for getting software onto your server. Ubuntu provides three official repos by default for Ubuntu 20.04 LTS: focal, focal, focal-updates, and focal-backports. You can browse their contents at **https://packages.ubuntu.com**, and these can all be installed from the command line as soon as you log into Ubuntu Server for the first time.

The biggest issue with Ubuntu's package archives is that many applications found here are frozen at the point of Ubuntu 20.04's release, so any subsequent developer updates are ignored until your next major upgrade (22.04 isn't due until May 2022). One prime example of this is Cockpit, which is 'stuck' at version 215 in Ubuntu 20.04 (27 updates have been released since then).

Many applications offer their own repositories, which work in the same way as Ubuntu's own: once installed, they're accessible via the "apt" command, and whenever new updates are released, you'll be informed of them via Software Updates. Muddying the waters further, Ubuntu's developer Canonical has developed "snaps," which are installed using the "snap" command. Once in place, snaps then update automatically as soon as the developer releases a new version.

Apps can exist in multiple repos as well as snap – if an app exists as a snap (use the "snap find appname" command to verify if it does), then installing through here rather than the focal repos will ensure your apps remain up to date. If they're not on snap, visit the software's website to see if it provides its own repo. Add this as instructed, then use "apt" in the usual way to install the package.

and click the "Ubuntu Server" link, followed by "Option 2 – Manual server installation." You should find the latest LTS version (Ubuntu Server 20.04.2 at the time of writing) as the main option. Click this to download the installation media in ISO format – this will download the amd64 build, which works with regular Intel and AMD processors, including the Pentium Silver J5040.

It's a much smaller download than the full-blown desktop version – a mere 1.1GB. Once downloaded, you can burn it to a blank DVD or use a tool like Rufus (follow the guide at **http://bit.ly/MPCubuntuinstall**) to copy it to an unused USB flash drive (2GB or larger).

Once you've created your install media, plug it (or insert the disc) into your server PC before powering it on. If you've not already done so, have a quick comb through the BIOS to see if there are any settings you should apply – for example, J5040-ITX users should navigate to "Advanced" and enable "SATA Aggressive Link Power Management" to save energy.

If the BIOS isn't configured to automatically boot from USB drives, tap the F11 key on startup to bring up the boot menu, then select your USB drive to start the install process. If you're familiar with the Ubuntu Desktop install process, prepare to forget everything – the Server uses a text-based install method.

When the GRUB menu appears, leave "Install Ubuntu Server" selected, and press Enter. You'll see some familiar command-line messages scroll by as your drive is tested for errors and key steps are performed. Eventually you'll be shown the text-based setup menu – not as attractive as Ubuntu Desktop, certainly, but still relatively simple to navigate.

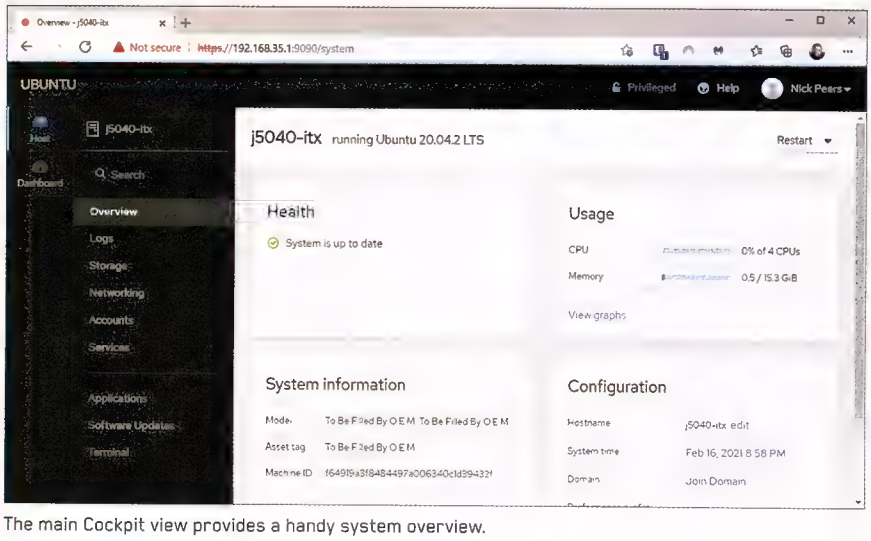
Set up your system

Select your preferred language and hit Enter, then choose your keyboard language and layout. The next step is potentially the trickiest, as it involves configuring your network. Servers should be given static IP addresses so they can easily be found on the network, so start by pressing the up arrow key twice to select the current interface (ETH or WLAN) and press Enter. Use the down arrow key to select "Edit IPv4," hit Enter, then hit Enter again to change the setting from "Automatic (DHCP)" to "Manual."

You'll now be asked to set this up, using the down arrow key to move between fields. Ordinarily, you'd expect to enter 255.255.255.0 under "Subnet," but instead type "192.168.x.0/24", substituting "x" with the figure shown under DHCPv4. Enter your desired IP address into the "Address" field – making sure it doesn't clash with other network devices – and your router's IP address into the "Gateway" field.

"Name servers" is where you enter your chosen DNS servers – typically 8.8.8.8,8.8.4.4 for Google, or 1.1.1.1,1.0.0.1 for Cloudflare. The "Search domains" field is only required if you want to append a local domain to hostnames across your network – for example, "mypc.mydomain.com". If in doubt, leave blank. Once done, select "Save" and hit Enter. Once the changes have been applied, select "Done" and hit Enter. Skip the "Proxy address" field, and leave the default Ubuntu mirror address selected too.

"If you're told you don't have the right to shut down or restart the server, it's because you didn't leave "Reuse my password..." ticked when logging in. "



The main Cockpit view provides a handy system overview.

Next, configure your storage. Assuming that the entire boot disk is being given over to Ubuntu, leave "Use an entire disk" selected, along with "Set up this disk as an LVM group" and move on, accepting the filesystem summary (advanced users can select the custom setting to set up separate partitions for root and home directories if they wish). The point of no return comes with the "Confirm destructive action" dialog – select "Continue" to accept these changes.

Next, you'll be prompted to set up your user account – which works in the same way as any Linux/Ubuntu installation – along with your computer's name that will be used to identify it on your network. Next, you'll be given the option of installing OpenSSH for secure remote access to your server via a command-line tool like Putty – not strictly necessary given you'll soon have browser access via Cockpit.

Snap to it

The setup tool will now provide you with a list of optional apps and components you can install via snap (see page 82) – we'd recommend installing Docker and Canonical-livepatch (the latter will ensure you're protected automatically with the latest security patches, without having to manually apply updates or reboot).

When you click "Done," a log screen will appear, revealing that the installation has been preceding in the background and may now be all but complete. Simply wait while security patches are applied, and select "Reboot Now" when it appears as an option. Unplug or remove your install media, and let Ubuntu Server boot.

If all is well, you'll see the usual startup messages appear, then replaced by an option to log into your new install. Enter your username and password to do so. Don't be alarmed if additional messages scroll by – on our test machine, Docker was installed after the first login, along with additional cloud-config configuration.

Once you've booted in, set up your new web-based UI, so you can start running your server headless and switch to what will become your day-to-day user interface: Cockpit. Issue the following commands to get it installed (along with any required updates to existing packages – you'll usually find a dozen or so):

```
$ sudo apt update && sudo apt upgrade
$ sudo apt install cockpit -y
$ sudo systemctl start cockpit
```

Once everything is complete, verify that it's active and running ("sudo systemctl status cockpit"), and if it is, you're now ready to administer your server from any PC on your local network.

Start using Cockpit

To access your server remotely, browse to **https://192.168.x.y:9090/** in any web browser, substituting "**192.168.x.y**" with the address of your server. You can safely ignore any potential safety risks flagged by your browser – that's because Cockpit generates a self-signed SSL certificate for the IP address. When the security alert appears, follow your browser's advice for creating an exception to allow access (in Firefox, click "Advanced..." followed by "Accept the Risk and Continue,") and you'll be whisked to the login screen.

To log into the web interface, enter the same username and password you set up during the install process – in other words, your regular Ubuntu Server login details. Assuming you're on a secure PC, leave "Reuse my password for privileged tasks" ticked, then click "Log In."

You'll find yourself at the main cockpit screen in the "Overview" section, which provides a handy summary of your server's status, as well as a shortcut for shutting down and restarting the system. If you're told you don't have the right to shut down or restart the server, it's because you didn't leave "Reuse my password..." ticked when logging in. Similar elevated functions, such as checking for updates, will also be disabled, and you'll see an "incorrect password attempt" error appear in the system logs, which can be safely ignored.

Elsewhere on this screen, "Health" gives you a quick overview of whether any updates require installing. as well as potential problems (such as services failing to start), while "Usage" lets you monitor your CPU and memory. "System Information" provides a shortcut to an overview of your server hardware, and "Configuration" provides some useful information, plus the ability to change your server's hostname if you so wish.

Fix Cockpit networking issues

On the left of the Cockpit window you'll find shortcuts to all the features that Cockpit offers. Before going further, however, the Networking and Software Updates aren't configured correctly in Ubuntu 20.04, so we'll need to edit a configuration file, and reboot to fix the problem and make Cockpit fully functional.

To do this, select the Terminal shortcut, which works just as it does in Ubuntu itself. There's Tab autocomplete to speed up path and filename entries, and it's fully compatible with the clipboard too, making it easy to copy and paste commands from elsewhere, including webpages. In the Terminal, type the following command:

```
$ sudo nano /etc/netplan/00-
```

Back up your system

We're sticklers for backing up at *APC*, so we're not going to let you off the hook. Every now and then you might want to try something on your server that either fails to work or breaks something else in the process. Thanks to timeshift you can roll things back, just like Windows' System Restore:

```
$ sudo add-apt-repository ppa:teejee2008/timeshift
```

```
$ sudo apt update && sudo apt install timeshift
```

Type "timeshift" after installing to get a rundown of all available commands, but the following will perform your first backup, which will be stored your boot partition:

```
$ sudo timeshift --create --comments "A new backup"
```

Scheduling backups from the command line is tricky – you'll need some working knowledge of crontab – but it's easy enough to run manually on demand, such as before major updates or installations. Then, should you ever need to restore a backup, simply issue the following command:

```
$ sudo timeshift --restore
```

You'll be prompted to choose which backup to roll back to (which is where the comments come in handy), and whether to reinstall the GRUB bootloader. One reboot later, and your changes will have magically vanished.

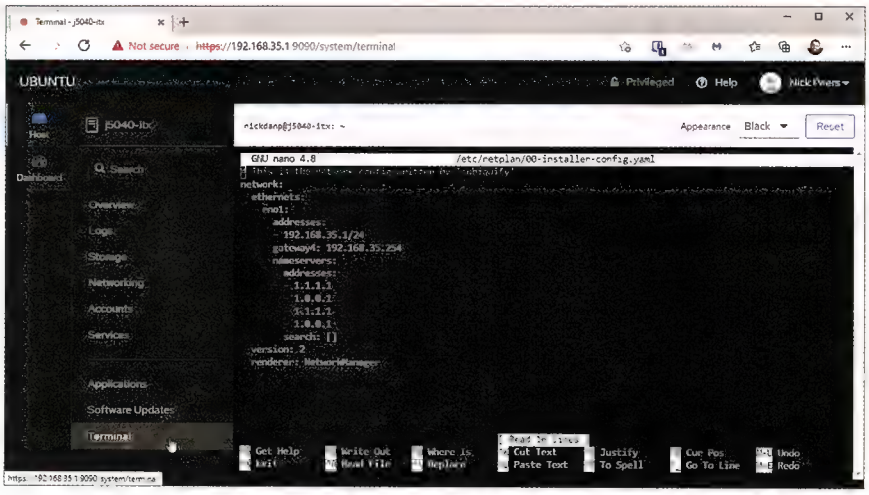
If you'd prefer to administer your backup from your browser, then examine BorgBackup (**https://borgbackup.readthedocs.io/**) as an alternative. It's quite a lot more fiddly to set up, but the final results should be worth it.

installer-config.yaml

This will open a configuration file. Add the following line beneath "version: 2":

renderer: NetworkManager

Press Ctrl-X followed by Y, and Enter to save your changes. Reboot your server.



Add this line to ensure Cockpit plays nicely with Ubuntu 20.04.

Complete the Cockpit tour

Once you've logged back in, pick up where you left off. "Dashboard" links to performance-related graphs (also accessible elsewhere in Cockpit, which is why the feature's been removed from later builds), while "Host" houses shortcuts to all the parts of your system you can control via Cockpit.

"Logs" provides you with a handy look at your system logs, while "Storage" gives you both an overview of any drives connected to your PC, as well as the tools for formatting and mounting them (more on that shortly). "Networking" works in a similar way – not only can you monitor your network connection, but you can configure additional networking interfaces, plus make changes to your main interface by rolling over it under "Interfaces" (it should turn blue), and then clicking it. From here, click the IPv4 entry to make your changes.

"Accounts" enables you to view, modify and add new accounts to your system, with options to force regular password changes, as well as adding authorised public SSH keys. You can also forcibly disconnect other users who are logged on to Cockpit from here, by clicking the user followed by "Terminate Session."

"Services" gives you an overview of all the various background processes running on your system, and you also gain the ability to manually stop, start and auto-start them from here. The "Applications" section is where any plugin modules that extend Cockpit's functionality can be found – by default, only "Storage" is set up. This is where the Docker plugin will appear when we add it later. Last is "Software Updates," a convenient place to check for, apply, and review previous updates to your system now that it works correctly.

"Some services are best run in their own isolated environments for security and stability reasons. That way, if the service runs into a problem, it can't bring down your entire system."

Configure your storage

Now you've got Ubuntu Server and Cockpit up and running on your main boot drive, it's time to configure the additional drives you've physically installed. Before doing so, however, let's take a few precautions and instigate a robust backup system – see the box opposite for details.

Once done, return to configuring your drives. It's a relatively straightforward process, but it does assume that you have a working knowledge of how Linux views drives and partitions – namely, they're mounted as folders within your filesystem, hence the need to set what are known as mount points.

Before going any further, you need to create these directories. To keep things simple, we suggest housing the links within your own personal home directory to avoid permissions issues. Open the Terminal and enter the following:

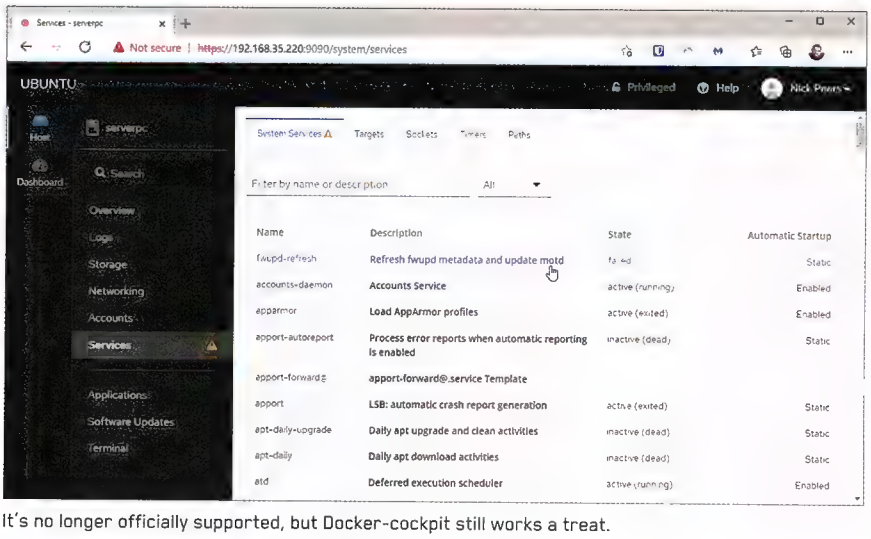
$ mkdir ~/media

$ mkdir ~/media/bay1

You're now ready to partition, format, and mount your first drive. Switch to the "Storage" section, and scroll down to the "Drives" section, which lists all the physical drives you've installed – note, we're assuming they're currently unformatted. /dev/sda refers to your boot drive, which you obviously set up during installation, so move on to /dev/sdb, which you should be able to confirm is the correct drive by its capacity. Click this to access its own properties screen, where you'll see that it's listed as "unrecognised data" under "Content." To fix this, click "Create Partition Table," choose your partition type (MBR or GPT, leave the latter selected if unsure) and click "Format."

With the basic partition table in place, click "Create Partition" to open a new dialog that makes it easy to partition the drive as you see fit, using the slider if necessary to create multiple partitions on the same drive, one after the other. We recommend you select ext4 as your file type rather than the recommended xfs, which is geared more towardsenterprise-class OSes, such as Red Hat.

Give your drive a suitable name – consider naming it for the mount point you created earlier (such as Bay1) – and then enter the path to the mount point



It's no longer officially supported, but Docker-cockpit still works a treat.

– /home/<username>/media/bay1. You'll see options for read-only mounts and custom mount options, but leave "Mount now" ticked, before clicking "Create Partition" and waiting for the process to finish (it can take a little while).

Once complete, you may see a warning sign next to the drive – if this happens, click the warning, and choose to mount now, which should complete the job and permanently give you access to the drive and its contents via your chosen mount point. If you have more drives installed, repeat the process for each drive – /dev/sdc, /dev/sdd, and so on.

Set up folder sharing

Next, it's time to configure your shared folders. To ensure that you can access them from any OS, you'll need to install Samba. The following sets up both Samba and a shared folder inside your newly formatted hard drive:

```
$ sudo apt install samba
$ mkdir -/media/bay1/shared
$ sudo nano /etc/samba/smb.conf
```

Add the following code block to the bottom of the file (don't forget to substitute <username> with your username):

```
[shared]
    comment = Ubuntu Shared
    path = /home/<username>/media/bay1/shared
    read only = no
    browsable = yes
```

Save the file, exit Samba, and issue the following two commands:

```
$ sudo service smbd restart && sudo ufw allow samba
```

Finally, assign a special Samba password to your user account to gain access to the shared folder from other computers (make sure it's different to your system password for obvious reasons):

```
$ sudo smbpasswd -a <username>
```

You should now be able to access the shared folders from other devices on your network using the username and password you just configured. If they don't show up automatically, type **\\192.168.x.y** (substituting "**192.168.x.y**" with your server's IP address) into a Folder Explorer window to manually access the shares.

Moving forward with your new server

The basics are in place. Now you're ready to have fun. Start by installing the packages you need to deliver the services you require. If you want to quickly and easily transfer data from elsewhere on your network (such as a gigantic folder of media files) without opening up any shared folders, you could use a sync tool like Syncthing (**https://syncthing.net/downloads/**) to do the hard work.

When it comes to setting up your media server, both Plex and Jellyfin are good choices, and should be installed directly onto your server via their respective repositories, so you can take full advantage of hardware transcoding to relieve the burden on your server. For more on the various ways of getting up-to-date software on to your server, check the box "Snaps versus repos" on page 84.

Work with Docker

Some services are best run in their own isolated environments for security and stability reasons. That way, if the service runs into a problem, it can't bring down your entire system. One way to do this would be to set up multiple virtual machines, but setting up a dedicated VM with its own operating system and overheads is an impractical (never mind wasteful) use of your server's fairly limited resources.

An alternative approach is to use what are known as "containers," which can be thought of as "thin" VMs that contain only the bare requirements – dependencies, configuration files and so on – needed to run the service in question. The best-known implementation for containers is Docker, and that's what we're using in this feature (see the "Docker versus Podman" box for why Docker is no longer officially supported by Cockpit, and the reasons why we're sticking with it for now).

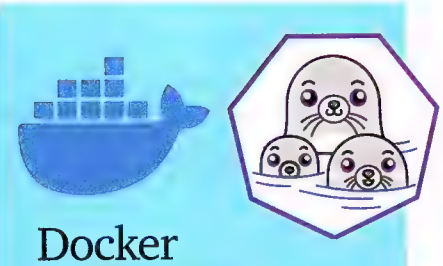
While Docker-cockpit is no longer officially supported, it still works fine. Here's what you need to do to obtain and install it:

```
$ wget https://launchpad.net/ubuntu/+source/cockpit/215-1~ubuntu19.10.1/+build/18889196/+files/cockpit-docker_215-1~ubuntu19.10.1_all.deb
$ sudo apt install ./cockpit-docker_215-1~ubuntu19.10.1_all.deb
```

Once installed, log out and back into Cockpit, and you'll see a new option – "Docker Containers" – appear on the left of the screen. Select this, and you'll discover the joys of running and managing containers without having to get tangled up in the command line. And unlike frustrating experiments with Podman, it works straight off the bat too.

You'll also see a new option appear under "Accounts" when you click on your user account: "Container Administrator." This basically adds the selected user to the "Docker" group to let them run Docker from the command line without requiring the use of "sudo."

Now that you've set up the fundamental parts of your NAS server, take another timeshift backup. Once that's done, you're ready to get on with making the most of it. ■



Docker *vs* Podman

When Cockpit was first developed, it had plug-in support for administering your Docker containers remotely via its user-friendly web interface. But then Red Hat OS became a major backer of Cockpit, and when Red Hat developed its own alternative to Docker – Podman – the developers were quick to drop official support for Docker in favor of Podman.

Podman and Docker both support the same container types, and Podman uses the same command structure as Docker – indeed, Red Hat recommends the "alias docker=podman" command to minimise disruption when switching from Docker to Podman. Podman has two key advantages: each container runs within its own self-contained process; and it supports "rootless" containers, namely containers that can be run using non-root user accounts for greater security.

Given this, you'd expect us to embrace Podman fully in this tutorial. And that's what we intended to do. But Podman is still relatively young, and major releases keep breaking functionality, particularly on lesser supported distros like Ubuntu. At the time of writing, Podman's rootless support is hit and miss in Ubuntu – and that's being generous.

Thankfully, while Cockpit's developers have dropped support for Docker, you can still install the plug-in manually. So that's what we've decided to do for this feature: we're going to stick with Docker, and give Podman time to develop further and iron out its teething problems. And don't worry about missing out on Podman's rootless support - you can configure Docker containers to run using a specific user account with just two environment variables (see **https://docs.linuxserver.io/** for more details).

QUICK TIPS

APC experts solve computing problems

The *APC* team tackle problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Backup and reinstall

I would like to know how to make a backup of my entire computer. Also, I would like to download a brand-new install of Windows 10 64-bit. My version was previously one downloaded by an employee of Office Depot. Unfortunately, I don't have a copy – this could be a problem if my computer crashes, as I'll have nothing to show for it. Please advise.
JERRY YARON

APC responds: Go to **www.macrium.com/reflectfree.aspx** to download and install Macrium Reflect Free. Once installed, open Macrium, and, assuming that Windows, your apps and all your personal files are on a single drive, choose "Create an image of the partition(s) required to backup and restore Windows," then follow the prompts to create a recurring backup to your hard drive. Choose the "Differential Backup Set" template for a sensible backup regime, involving daily "differential" backups to keep the backup size down. Choose "Other Tasks > Create Rescue Media" to create emergency bootable media on CD or USB flash drive so you can recover your backup if Windows becomes unbootable.

You can create your own Windows installation media by downloading the Media Creation Tool from **www.microsoft.com/software-download/windows10** – use this to create a bootable USB flash drive, which you'll be able to use to reinstall Windows from scratch on your computer, should the need arise. The key thing is determining what kind of Windows 10 license is on the computer – if you log into Windows 10 using your Microsoft account username and password, then it's a digital license. What this means is that you can skip the prompt for a product key during installation, and Windows 10 will automatically reactivate after you've set things up from scratch.

Online ticket tips

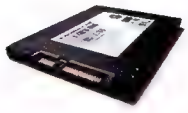
I frequently book tickets to events that tend to sell out quite quickly – sometimes in a matter of seconds. The usual process is to press Enter and then get an option with available tickets, but when I select them and hit Enter again, the ticket is frequently no longer available, and I have to repeat the process – either getting inferior tickets or sometimes nothing at all.

Therefore, I'm trying to set up a dedicated internet approach to maximise my responsiveness in these situations. My computer is an older PC with an Intel i7 processor and connected to my cable internet connection via a Gigabit Ethernet cable. OS is Windows 10 Pro and is up to date.

I currently use Firefox, which is perfectly satisfactory for day-to-day browsing. I have many bookmarks and it's probably quite full up with browsing history, and so on. I've been reading that there are several settings that can be changed to increase Firefox's "speed" but I'm reluctant to mess around too much in case I inadvertently worsen its overall performance.

I also recently read that Vivaldi would be a faster browser so I may install Vivaldi for this one function – then it would not be saddled with the inevitable accumulation of history and so on. I'd appreciate any guidance you can provide – for example, would it help to shut down unneeded programs while trying to book a ticket? Also, any settings I might change in Firefox or Vivaldi if that seems the best route?
GORD MACDONALD

APC responds: Perhaps the issue here is that you're reduced to taking part in the general melee that occurs whenever tickets go on sale to the wider public. If an event is particularly popular, you might want to consider a different approach: look for presale offers, such as joining a fan club or signing up for a specific credit card when an event is due to go on sale. Not only do you get the jump on the great unwashed, you'll unlock better seats in the process. Also, see if you can source the tickets elsewhere – try the venue directly, for example.



HP's S700 Pro is an affordable and long-lasting SATA SSD.

Otherwise, you might want to consider whether your computer is actually the best platform to buy those tickets on. Ticketmaster's mobile app is considered faster and more efficient than sitting on your web browser, for example.

If you're going to stick with your PC, though, there are some other considerations: is your internet connection fast and stable enough? Once you've selected your tickets you should be able to complete the checkout process without losing them or your place in the queue, but if your connection drops or is too slow, then you're back to square one. The quality of your connection is determined by its signal levels – see **tinyurl.com/APC493SPD** for a generic guide, using your router's administration tool (accessible by typing its IP address into your browser) to measure your current settings. If you see problems, talk to your ISP.

We also like the idea of trying a different browser, but not necessarily for the reason you're thinking. He's wondering if ticket websites are optimised for Chromium-based browsers over Firefox's Gecko engine, for the simple reason that they're far more popular: Chromium browsers cover Vivaldi, Edge, Opera, and of course Google Chrome. With this in mind, you won't lose out by trying it.

CAPTCHA tests are another bane of anyone attempting to jump through ticket sales, so if you find yourself losing valuable time to these checks, try a browser plugin that can safely disable them—many like AntiCaptcha (**https://anti-captcha.com**) charge a small sum ($1 will cover 2,000 images) but can circumvent most CAPTCHA tests pretty quickly. If you want to try a free service, then Buster

(**https://github.com/dessant/buster**) is one to try. Test this on an event that's less likely to sell out to see whether it has any positive effect on your ticket-purchasing process.

If all else fails, try Googling "Ticketmaster tips" or whichever ticket website you're trying to get tickets from – you'll find plenty of tips and tricks that may improve your chances going forward.

Gateway all-in-one upgrades

In this time of low supply and high cost of PCs, I am trying to get by with a Gateway ZX6971-UB2OP. I would like to upgrade some components, to make it more usable. One thing I know about this device is none of the components are easily accessible like a laptop. Based on my experience with opening laptops, I will take it to a shop to install the new parts.

My issue is getting the right parts ahead of time. With Gateway being out of business, and their support site very small, it is hard to know what I need. I want to add more RAM, yet some resellers say I can use two sticks of 4GB DDR3 RAM while others state 2 x 8GB. I also want to swap out the HDD for an SSD. I'm sure it only supports 2.5-inch drives, but not sure what brackets will be needed. Also, one of the fans is very noisy, and therefore likely at the end of its life, but again, not sure what sizes to get. Any ideas where I can find all this information?
AL HOWARTH

APC responds: We saw your query on Reddit, which elicited just the one response – one that directed you to a YouTube clip that appears to cover disassembling a different model. However, searching YouTube for "ZX6971" reveals numerous disassembly videos that will probably reinforce your decision to get someone else to fit the upgrades for you.

The videos made it difficult to work out if the existing drive is 2.5-inch or 3.5-inch, but that doesn't matter – the SSD can either be screwed into the existing metal cage, or simply secured to the chassis using double-sided tape. Your PC's SATA-II interface limits you to 3GB/s transfer speeds, so don't break the bank looking for a performance-driven SSD, you'll still benefit from much faster transfer speeds.

In terms of upgrading the RAM, we took a trip to Crucial (www.crucial.com) where we were able to select your exact model from the memory-finder tool. This recommends no more than 8GB in total (2x4GB). Sadly, all available modules were listed as out of stock; however, it reveals you're looking for DDR3L-1600 SODIMM laptop memory (specifically PC3-12800, CL=11, Unbuffered, NON-ECC, DDR3-1600, 1.35V) and can redirect you to www.staticice.com.au: you'll find that a 4GB module currently costs around $25 (so $50 -$60 in total for an 8GB upgrade).

Finally, we had to dig deep to track down the replacement fan you'll need. Go hunting for the following part numbers: BUB0812DD-BD88 or 1323-00DY000 – the fan fits several models, including Acer All-in-One machines as well as Gateway. Expect to pay around $40 for the fan.

Possible laptop hack

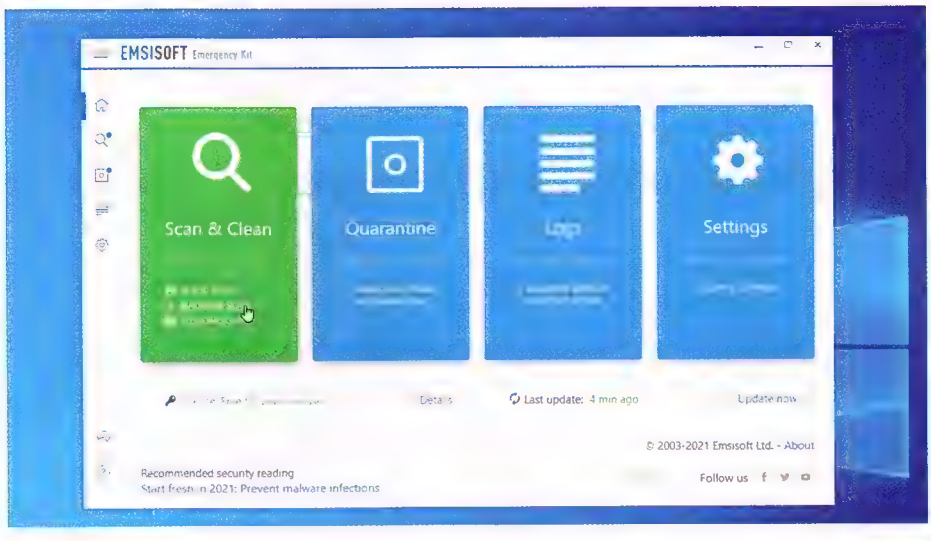
Our laptop has been hacked: The Windows 10 admin password has been changed, as have two Excel spreadsheet passwords. Now the only way I can log into the laptop as an admin is using the fingerprint scanner.
LARRY

APC responds: Larry also followed up with another email saying that his laptop takes 8-15 minutes to fully boot, and that the hard drive runs continuously. All of this is probably related, which means we'd recommend you disconnect it from the internet, and then take steps to run full security scans with both your existing security software, and then using a series of third-party tools, which you should download on another, clean computer before transferring across to your infected laptop.

Two tools you can run directly from Windows as portable scan-and-remove apps are Emsisoft Emergency Kit (get it from **www.emsisoft.com/en/software/eek/**) and VIPRE Rescue (**www.vipreantivirus.com/vipre-rescue-virus-removal-tool.aspx**) if EEK doesn't work. Failing that, try a free bootable rescue disc such as Kaspersky Rescue Disk 18 (**https://support.kaspersky.com/krd18**). If nothing is found, and you can still install software on your infected laptop, download the free version of Malwarebytes Anti-Malware (**www.malwarebytes.com**) on your clean machine, then transfer it across and install it to run a deeper scan for other potential infections.

Assuming it finds and removes any infections, you're left with the clean-up process. If you log on to Windows using a Microsoft Account, then visit **https://account.microsoft.com** to verify that the password has been changed, and then take steps to recover your account (go to **https://account.live.com/password/reset** if necessary).

For your Excel passwords, you'll need a tool like Excel Password Recovery (**www.thundershare.net/free-excel-password-recovery/**) – use the free version to determine if it can guess the password, then purchase a single personal license for US$39.95 to unlock the files for use again. ■



Emsisoft utilises two antivirus engines to scan your machine.

Switch audio output with SoundSwitch

Take control of your PC's audio via this clever and versatile app, with Ian Evenden.

The back of your PC probably has both analog and digital audio outputs. Then there are Bluetooth headphones, USB headsets, the speakers on your monitor connected over HDMI, even external sound-processing boxes. For something that can't generate more than a harsh beeping noise unaided, your PC can actually find many ways to make a noise.

Windows doesn't always make it easy to switch between them, though, and is always liable to blast audio through your speakers when you don't want it to, or to remain stubbornly silent when you try to connect something to its digital optical output.

SoundSwitch is an open-source utility that sets your PC's audio output, and lets you choose a hotkey so you can swap the noise from speakers to headphones quickly. And it does the same for recording inputs too. It's the work of coder Antoine Aflalo. Here's how it works.

Get started

You read *APC*, so we don't need to tell you how to install this app. Once you've got it running, go to the Settings page. Here you can configure the app, tell it which inputs and outputs you want to switch between, and which combination of keys you want to use to do it. Settings opens automatically once you've finished installing, or you can right-click the icon in the System Tray and open it from the pop-up menu.

Outputs

SoundSwitch is an unobtrusive app. Set it to start with Windows, and it sits in the System Tray. The first tab of its Settings page is Playback, where you choose the output your PC audio should use. Initially, you're presented with a list of every output installed on your machine, sorted into those that are connected and disconnected [Image A]. Put a check in the box next to the ones you'd like to use, then set the hotkey below (we found the default of Alt-Ctrl-F11a bit unwieldy, so try choosing a simpler one that doesn't clash with others you've got set up), and ensure there's a check in the "Hotkey enabled" box.

Inputs

The next tab, Recording, is exactly the same as Playback but handles your PC's audio inputs, such as webcam mics, headsets, and line-in sockets. It even picked up our cell phone thanks to Windows 10's A2DP feature, which lets you stream audio from a smartphone to your PC – presumably for recording purposes, as why wouldn't you just connect it straight to your speakers? Anyway, set your input-switch hotkey and move on.

Profiles

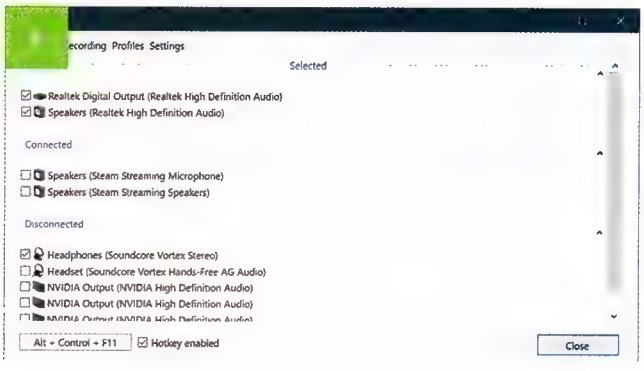
One of SoundSwitch's cleverest features, you can set it to automatically switch your input and output to specific devices when a trigger event happens, such as it detecting Steam's Big Picture mode, a specific app opening, another hotkey, or just on PC startup. Add a profile from the Profiles tab, and configure it from the pop-up. When the trigger conditions are over – for instance if you close Big Picture mode – SoundSwitch will return the audio settings to the way they were before.

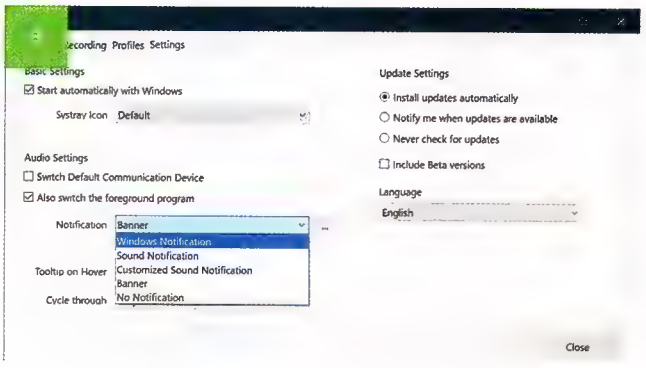
YOU'LL NEED THIS
SoundSwitch
https://soundswitch.aaflalo.me/

Settings

Settings within Settings contains settings for your settings – obviously. Here you'll find options to start the app automatically with Windows, install updates automatically, control tooltips, and choose what kind of notifications you receive. We like this last feature a lot, especially as it lets the app use Windows' own notification system [Image B], which keeps things tidy over to the right-hand side of the desktop, and can be blocked by Focus Assist. There's also a "No Notifications" option, and a useful sound notification that comes out of the newly selected output device, so you're doubly sure which one you're using. You can check what's selected at any time by hovering your mouse over the System Tray icon, and can control what information this tooltip contains.

Heartening to see is the large number of languages the utility is able to use – and there's a project running on the developer's site to translate it into even more.





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MAC

Get started with PCalc

Put away that scientific calculator – PCalc is your Mac maths master.

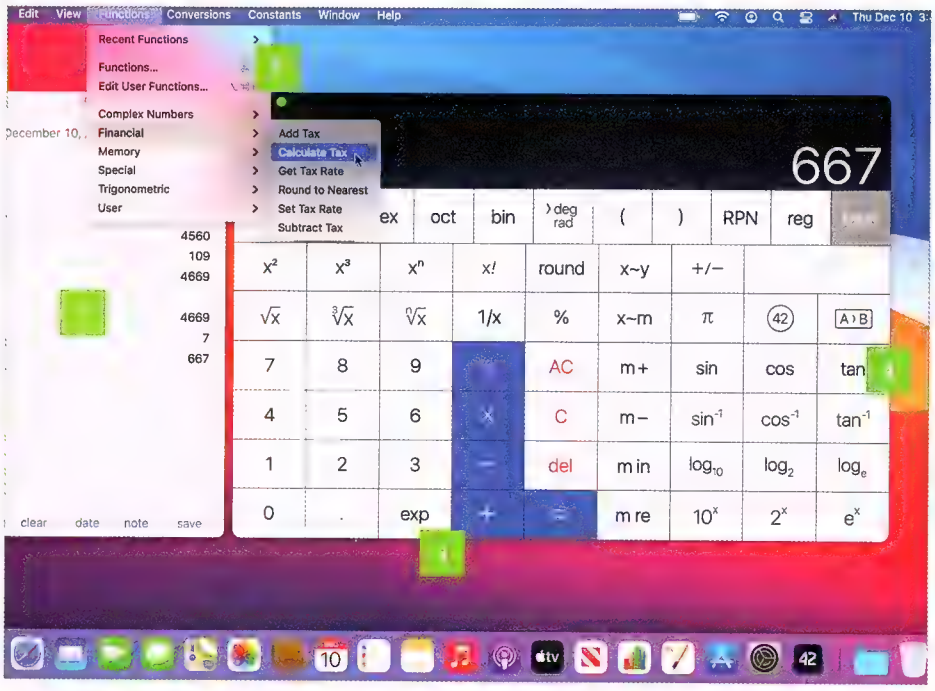
IT WILL TAKE
5-10 minutes
YOU WILL LEARN
How to use PCalc's basic features and start using the app
YOU'LL NEED
PCalc ($14.99), OS X 10.9 or later

If you want to run some calculations and conversions on your Mac, Apple's Calculator app and even Spotlight are decent places to start. But neither of those options offers anywhere near the level of depth, customisation, and power you get with PCalc. If you find they're missing the mark, PCalc is what you need.

The long-lived app has been around since 1992 – nearly 30 years! – yet is still going strong and feels right at home in macOS Big Sur thanks to its dedicated developer. It comes with a range of useful tools for almost any calculating need: switchable modes between binary, hexadecimal, octal and others, quick access to mathematical constants for use in your calculations (or simply for reference), conversions between numerous formats, and much, much more.

Despite possibly looking a little daunting to maths newcomers, it is actually very easy to use and full of useful options. In this tutorial, we will cover the basics of using PCalc, helping you to get started and well on the way to mathematical mastery. ALEX BLAKE

EXPLAINED... PCalc's main tools



TICKER TAPE
See your calculation history using the tape tool. You can add notes and output to a text file.

MENU OPTIONS
PCalc's menu bar is full of options, from basic timesavers to complex scientific functions.

CORE BUTTONS
Key buttons are found on the left-hand side of the app. These are the main ones shown in the Basic layout.

GO DEEPER
More advanced keys are on the right. You can alter what is shown here by changing the mode (step 3).

HOW TO Learn the basics in PCalc

01 STYLE IT UP

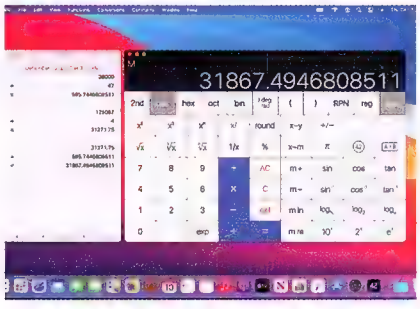
PCalc has a huge number of themes, colours and fonts that you can change to suit your needs. Click View, then pick options from the Theme, Tint, and Digits menus. Each has a preview to show you what you are getting.

02 FIND THE RIGHT LAYOUT

You can change the layout based on the controls you need. Click View > Layout and pick an option. There are layouts designed for Mac, iPhone and iPad. Click View > Display to change how calculation outputs are shown.

03 SWITCH MODES

PCalc is well suited for whatever type of calculation you need to do. On the main app screen, click one of the dec, hex, oct or bin buttons to switch between decimal, hexadecimal, octal and binary modes as needed.



04 SHOW YOUR WORK

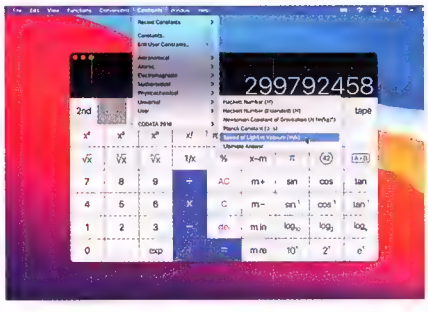
Sometimes it is useful to see your working out. You can enable this by clicking the tape button, or by clicking View > Show Tape. This opens a box showing your previous functions, conversions, calculations, and more.

05 WORK OUT YOUR TAX

Enter your pre-tax figure, then click Functions > Financial > Calculate Tax. The result is what you pay. Add tax to a number by clicking Functions > Financial > Add Tax. Change the tax rate in Preferences > General.

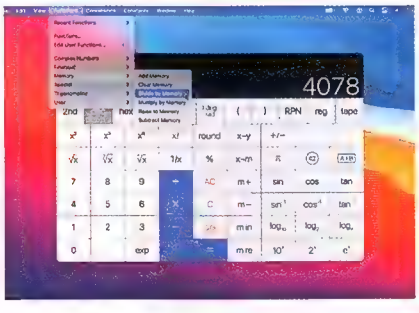
06 MAKE A CONVERSION

PCalc offers a huge range of conversions. Enter a number, then click Conversions in the menu bar and choose from currencies, lengths, energy, cooking, and more, or press command-B. Ensure you are in decimal mode first.



07 CONSTANTLY USEFUL

Want to use mathematical constants? You will need the Constants menu. This contains values for things like the Golden Ratio, the mass of the sun, pi, and even the mass of The Rock (yes, the actor and former wrestler).



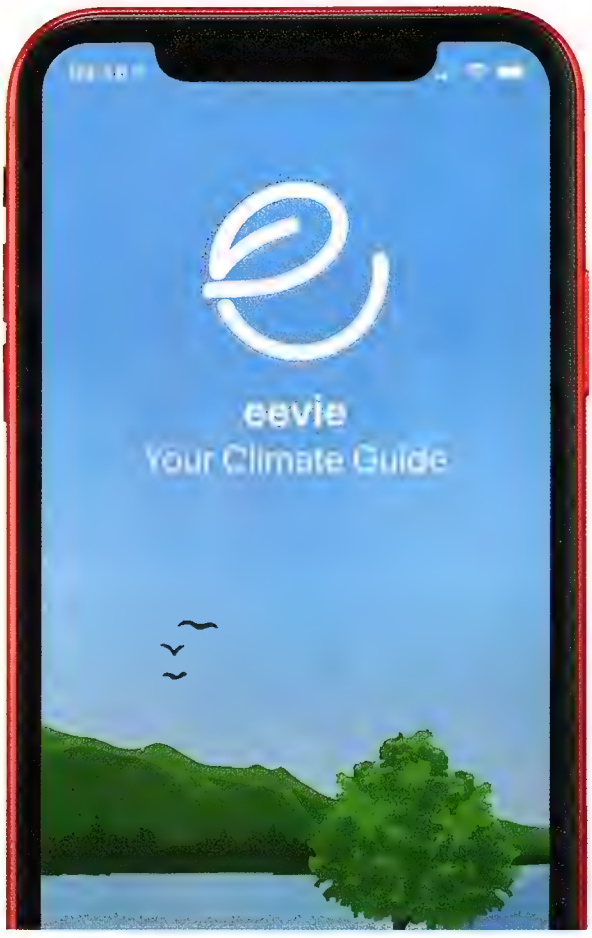
08 ADVANCED FUNCTIONS

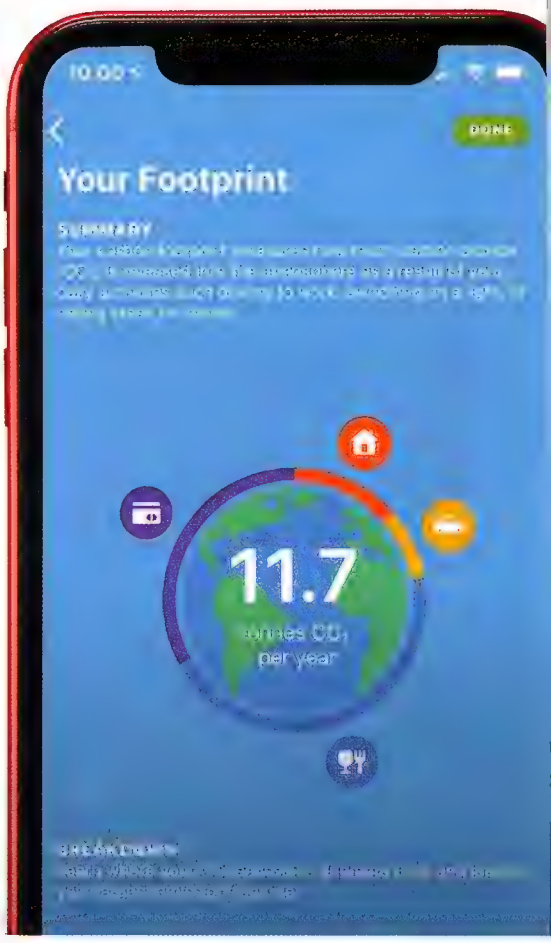
The Functions menu contains advanced tools. Here you can perform trigonometric calculations and use complex numbers in your work. It is also where you can run calculations using numbers stored in PCalc's memory.

09 LEARN THE SHORTCUTS

Acquaint yourself with the app's preset shortcuts in PCalc > Preferences > Shortcuts. These can be tweaked and set to only apply in specific modes. You can export and import shortcuts, reset them, and add your own.

GENIUS TIP!
Smart home devices – such as app-enabled thermostats – can cut emissions and costs considerably over their lifetime.





iOS

Cut your carbon footprint

Make the world a little bit of a better place and your bills smaller, writes Carrie Marshall.

Are you carbon neutral? Apple is set to be completely carbon netural by 2030, and its global corporate operations already are. And with the Eevie app, you can head in that direction too.

From driving cars and heating our homes to buying a brand new MacBook, the things we do have an environmental impact and lead to increased carbon emissions. Fortunately, we are now becoming more and more aware of the changes we need to make. We can change our habits in two ways. One, we can take steps to reduce our environmental impact; and two, we can offset our carbon emissions by contributing to projects that remove carbon from the atmosphere, such as tree planting.

IT WILL TAKE
A few moments per day

YOU WILL LEARN
How to reduce your environmental impact

YOU'LL NEED
Eevie – Your Climate Guide app (free), iOS 11 or later

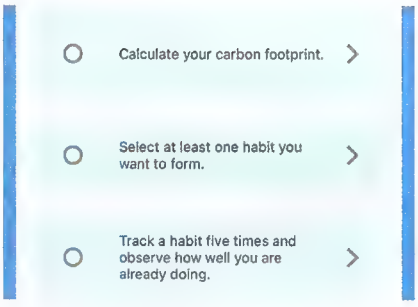
Eevie's calculations are based on pretty broad brush strokes regarding analysed information.

A little goes a long way

As we'll discover, Eevie helps you with both. It analyses your lifestyle to identify areas where you could make changes to reduce your environmental impact, and also enables you to contribute to worthwhile tree-planting programmes across the world.

One of the good things about apps such as Eevie is that they aren't just good for the planet. They're good for our physical and financial health too. Even little changes can go on to significantly reduce our environmental impact while also helping to reduce our energy and shopping bills.

HOW TO Reduce your environmental impact


Calculate your carbon footprint.
Select at least one habit you want to form.
Track a habit five times and observe how well you are already doing.

01 KNOW YOURSELF

Before you can make improvements to your carbon footprint, you need to know how big that footprint is. When you first run Eevie, it'll ask you to help it calculate your carbon footprint by answering a few simple questions.

02 COMPARE WITH OTHERS

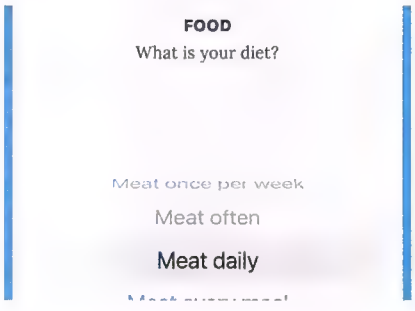
One of the things Eevie can tell you is how your carbon footprint compares with other people near you, and to do that it needs to know where you are. Tell the app which country you live in and then swipe for the next question.

03 SHARE YOUR SIZE

You'll need to know roughly how big your home is in order to calculate part of your carbon footprint. The floor space of the average new home in Australia is currently 186 square metres.

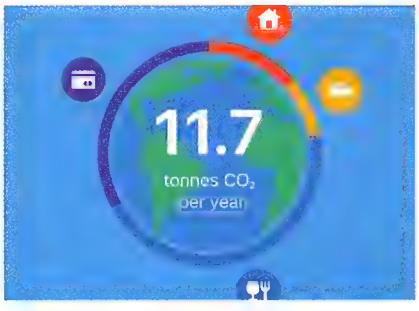
04 MARK YOUR MILEAGE

Car travel is a big contributor to your carbon footprint, so it's important to be honest here. The average Australian motorist drives up to 13,000 kilometres per year. Eevie's assuming you have a petrol or diesel car.



05 DESCRIBE YOUR DIET

If you aren't vegan, your dinner could be a surprisingly large contributor to your carbon footprint – and cutting down on your meat intake is the kind of lifestyle change that's not just good for the planet but good for you too.



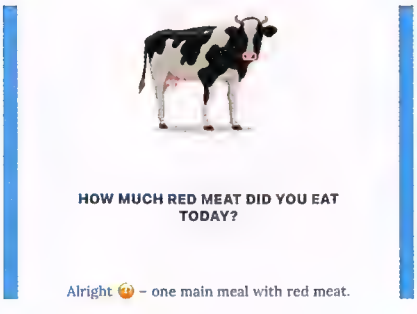
06 DISCOVER YOUR IMPACT

When you've answered all the questions, Eevie will show your estimated annual carbon footprint. It'll show you which parts of your life are having the biggest impact, and tell you how you compare to the national average.

Select a Habit
Switch Off Lights
Join 2863 others and start switching off unnecessary lights whenever you can. Receive reminders to help you make sure that all lights are off before leaving your home or going to sleep.

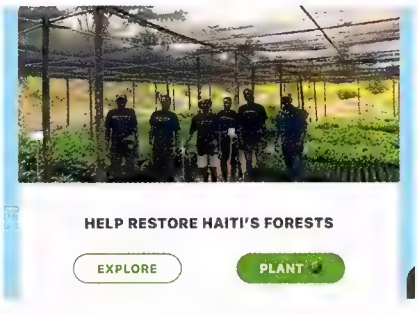
07 MAKE THE CHANGES

Eevie will now ask you to pick which changes you'd like to make and monitor. For example, you might decide that you need to turn off your smart lights rather than leave them on standby, or drive the car less, or eat less red meat.



08 TRACK YOUR HABITS

Once you've selected the things you'd like to change, Eevie will ask you to check in each day to record your progress and track your carbon reduction. If you enable notifications, it can also send you reminders.



09 PAY IT BACK

You can offset your carbon emissions by planting trees. Your first offset is free in exchange for inviting someone else to use the app; you can then buy points you can spend on tree-planting projects worldwide.

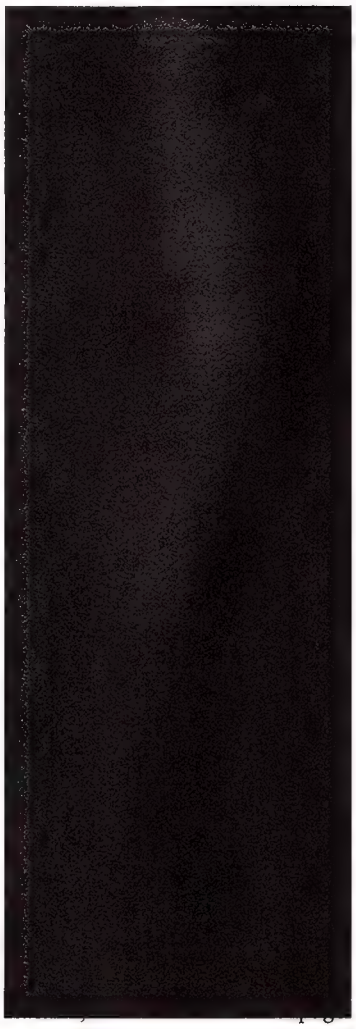
A terminal multiple window manager

You can't use the mouse or run multiple windows in a text environment... unless you're Shashank Sharma and know just the right tool for the job.

Terminal emulators and a text environment are quite different. For one, you don't have the luxury of using a mouse on a text environment, and you can't run launch multiple windows. Try one of your virtual terminals by pressing Alt-Ctrl-F1. The subject of this tutorial is Twin, which enables you to launch multiple windows in a text environment.

Twin (Textmode WINdow environment) is a window environment with mouse support and features a window manager and terminal emulator. It's different from tmux, which enables you to split your terminal into different panes and perform a variety of different tasks in each. In a nutshell, Twin is no different than having multiple windows open simultaneously on a graphical desktop environment.

For those of you who worked with DOS, back in the 80s, and before the release of Windows, DESQview was quite a rage for a brief period of time. Users were able to run multiple windows at the same time. Twin brings the same functionality to your Linux distributions.



Click the different windows to select one. If you click the empty blue area you'll bring up the global menu entries.

Getting started

You won't find Twin in the software repositories of Linux distributions. This means that you

File Window
[ ] New terminals start in UTF-8 mode
[ ] Always Show Cursor
[ ] Enable Blink/High Background
[ ] Hidden Menu
[ ] Menu Information Line
[ ] Menu Relaxed Arrows
[ ] Enable Screen Scrolling

also recommends running the `ldconfig` command afterwords. This is so that the project can easily find all the libraries.

You can now test twin by running the twin command in the terminal emulator of your choice. Before you switch to one of the virtual terminals to test the abilities of twin, you still need to perform an additional step. We need to start the gpm service so that the mouse support is available in the virtual consoles. You can do this by running the following:

```
sudo systemctl enable gpm
sudo systemctl start gpm
```

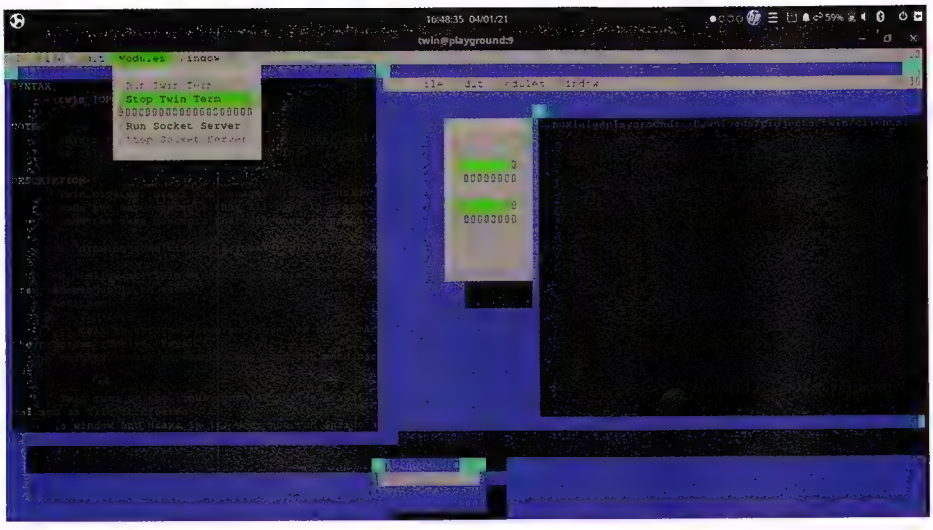
The first command, `systemctl enable` doesn't start the specified service, in this case `gpm` . It only configures the system to start the service at boot. To start the service, you must run the second command. Once you've enabled a service, you don't need to run the `systemctl start` command every time you reboot.

Working with Twin

We would advise you to get acclimatised to twin's working using a terminal emulator on your graphical desktop, before you decide to try it in the virtual terminal. This is because the quirky behaviour takes some getting used to.

When you first run twin, you're presented with what appears to be just another terminal console. The key difference is that there's a menu bar at the top with two entries: File and Window. Click either entry and keep the mouse button pressed to view what each has to offer.

For now, press `Ctrl-D`, or type `exit` to close the console window. The menu bar at the top now features additional menus. The Edit menu provides the usual entries such as cut, copy and paste. The Modules menu can be used to Run and Stop Twin Term as well as Socket Server. A window manager enables you to resize windows, roll windows to the menu bar, move windows and more. All these functionalities are provided as



different entries in the Window menu.

The window borders are customisable. These, and various other settings are configured using the ~/.twinrc file. The configuration file isn't created by default, but you can use the system.twinrc sample file provided in the Git repository. In addition to display, the config file can also be used to define keyboard shortcuts and tweak the operations associated with the left, middle or right click of the mouse. The sample file is thoroughly commented to help you make sense of the different sections and how they control the behaviour and functionality of twin. Run the `cp twin/system.twinrc ~/.twinrc` command to copy the sample file to the home directory. You can now edit the ~/.twinrc file in a text editor of your choice.

From within a Twin session, you can press the Alt-up arrow key to launch additional terminal session or click File>New Term.

Bundled applications

Twin ships with a number of applications, such as twcat, twsendmsg and twclutter. But you can't run them from within twin without first starting the Socket Server. Close the terminal if it's already open in twin, and then click Module>Run Socket Server and then File>New Term to launch a terminal session. You can now run the different applications, called clients or external programs.

The twattach and twdetach are quite useful. Using the twattach command, you can connect to an existing twin session from a remote host.

As a matter of practice, start the Socket Server when you begin a Twin session so that you can easily launch external programs.

From a twin session, first run the `echo $TWDISPLAY` command. The output would be a colon (:) followed by a number. Remember this number.

Now, from the twin session run `export TWDISPLAY=:<number>,gz` . Replace <number> with the number that we determined in the previous step. The ,gz option utilises gzip compression for connections. Now close the terminal session in twin and click File>Detach. This will close the twin window, but our twin session is still running. You can connect to this session at any time with the twattach command:

```
twattach --twin@:7 -hw=tty
```

You don't need to run twattach from inside a twin session. Any terminal session would suffice. The above command connect the detached twin session :7 to current display. Using the twattach command, you can also connect to a running twin session that hasn't been detached yet.

The same twattach command can also be used to connect to a twin session on remote machines. The only difference then would be that you have to use the IP address of the machines:

```
twattach
--twin@192.168.0.12:7 -hw=tty
twattach: libTw error: server
denied permission to connect, file
-/.TwinAuth may be wrong
```

You'll experience this error message the first time that you try to connect to a twin session on a remote machine. This is because twin uses the ~/.TwinAuth file to ensure that the server and client are trusted machine. To that end, the same ~/.TwinAuth file must be present on both of the machines. Once you've copied the ~/.TwinAuth file, you'll then be able to connect to a remote twin session using the usual twattach command.

The official tutorial on the project's GitHub page provides necessary information on how you can get the most out of twattach as well as the other bundled applications. Although at times terse, the tutorial is still well worth reading. ■

Taking screenshots

The Print Screen button on your keyboard provides a quick and easy way to take screenshots. Unfortunately, it doesn't work in the virtual terminals, leading most users to conclude that it's not possible to take screenshot of the different tty screens.

Most Linux distributions feature **fbcat** in their software repositories so run the **sudo apt install fbcat** or **sudo dnf install fbcat** command to install. The Fbcat package comprises two utilities: **fbgrab** and **fbcat**.

The fbcat utility creates PPM output that you can then convert using tools such as ImageMagick to create a PNG, say. The fbgrab utility, however, creates PNG screenshots, and is much faster.

You can easily take screenshots of virtual terminals (Alt-Ctrl-F1 through Alt-Ctrl-F6) using the fbgrab utility.

If you want to take a screenshot of the current virtual terminal, the basic **sudo fbgrab screenshot.png** command will do the job, and create the screenshot in your -/ directory.

You can use the **-s** command option to specify a delay, in second. The **-c** command option can similarly be used to define the virtual terminal. Remember, Alt-Ctrl-F1 is tty1, Alt-Ctrl-F2 is tty2 and so on. So, if you wanted to grab a screenshot of tty3, you could run the **sudo fbgrab -c 3 -s 2 -/Pictures/twin/screenshot.png** command, like we did to grab the first screenshot used in this tutorial.

OPEN SOURCE MASTERCLASS

The PiBook

Ian Evenden turns a Raspberry Pi into a Chromebook.

The beauty of single-board computers is that they can be switched between operating systems easily – it's just a case of swapping a microSD card over and switching it back on. The operating systems are easy to install too, flashed to a card from your PC with a user-friendly piece of software.

You can certainly install a full 64-bit operating system like Ubuntu on a Raspberry Pi, and get real work done on a diminutive PC. This time, we're going to do the same thing, but to the opposite extreme. Chromium OS – an open-source version of the Chromebook OS – is as minimal as things come without being a command line, as it's just the Chrome browser. But that doesn't mean it's particularly limited. There's a full office suite in there, cloud storage, image editors, e-book readers, and all sorts of other apps that are available as web apps. With no flashy interfaces or 3D games to distract you, working like this is a low-powered way to get everyday computing tasks done.

It's also quite responsive, which isn't something you can say for some of the heavier operating systems available for the Pi. We're using a Raspberry Pi 4 with 8GB of RAM here, but it will also run on a Pi 400, 3B or 3B+ model.

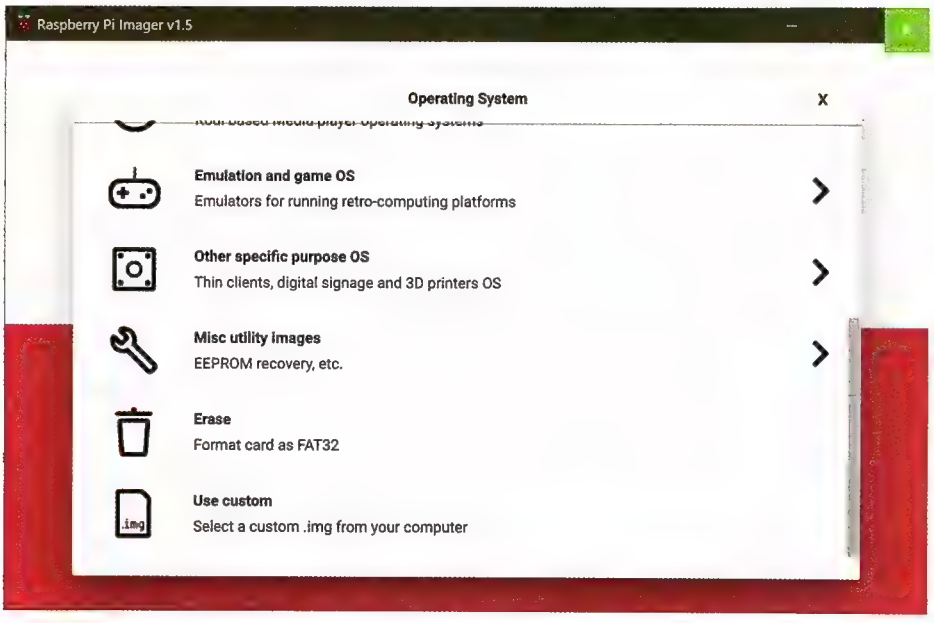
Flash

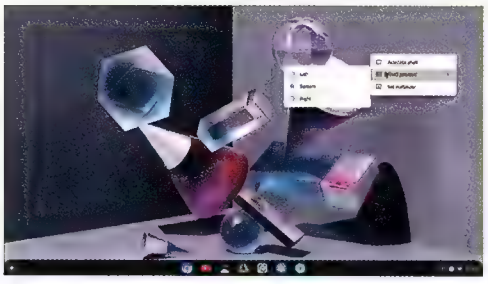
You'll need the Raspberry Pi Imager app to flash the ChromeOS build to a blank microSD card (Chromebooks typically come with 16 or 32GB of local storage, but this version only gives you 4GB, no matter how large a card you use – there's a way around this, though). The app runs on Windows, Ubuntu, Raspberry Pi OS, or macOS, and can be found at **www.raspberrypi.org/software**. Once that's installed, head to http://bit.ly/MPCaprfydeOS and download the Chromium OS image for your particular Pi model.

If you want to build the OS image yourself, head to the project's main Github page, and you'll find all sorts of discussion about that sort of thing, along with some known issues, one of which is important and we'll come to later. In the Imager, choose a custom OS, [Image A] then point it toward the IMG file you downloaded from Github. Choose the card you want to use, and set it working. We're using R86r2, released on December 30, 2020, but there may be newer releases by the time you read this.

Boot

Put the newly flashed card into your Pi's slot, and switch it on. The first boot can take a little while, but you'll soon be taken through the basic setup routines for the OS, including connecting to Wi-Fi. Chromium OS requires a Google account to sign in with, and if you're a Chrome browser user you get all your bookmarks and extensions synced across. We often find that there's a period of non-responsiveness on the password screen, but it usually clears after 30 seconds so you can log in. It's a minimalist UI, with a Mac-like dock at the bottom and the browser taking up the rest of the screen – but what more do you need?



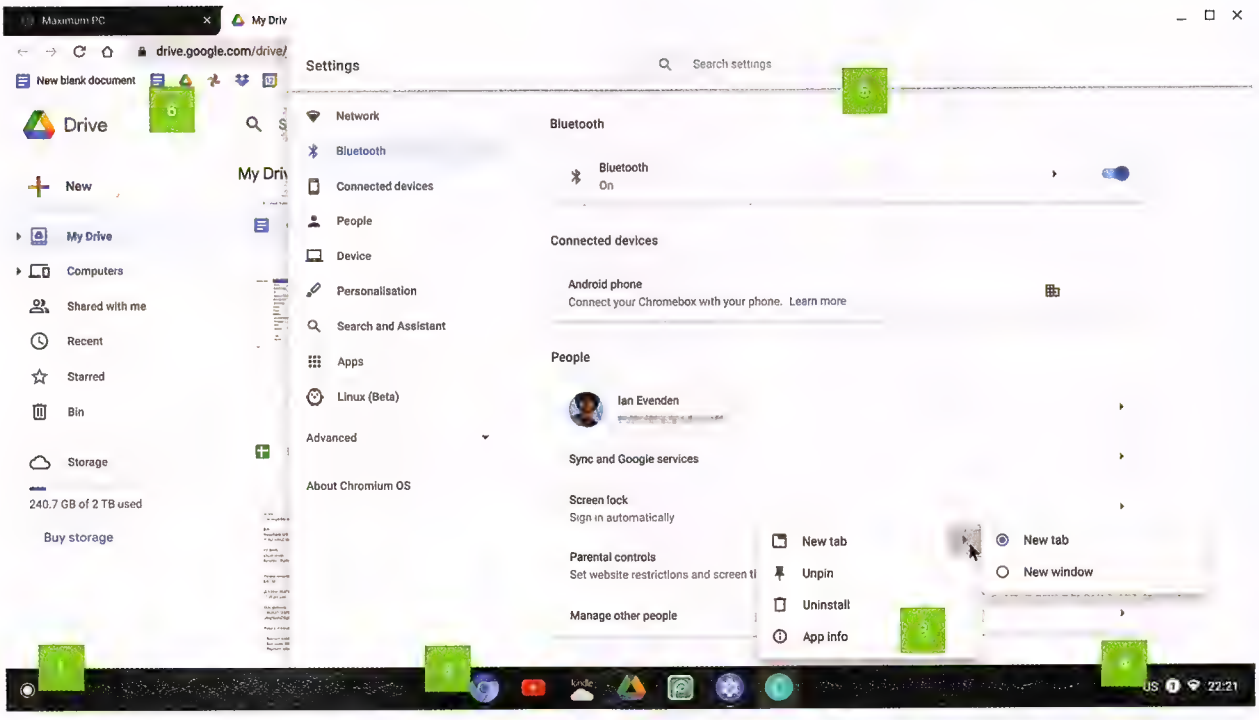


Wallpaper and customisation

Changing desktop wallpapers in Chromium OS gets its own app, accessible from "Settings > Personalisation." It's filled with desktop backgrounds, and a few have the option to refresh daily. There are some beautiful options available, but sadly they don't appear in the Files app. Right-clicking on the desktop gets you a menu, with only three options: to show or hide the dock (actually called the "shelf"); to position the shelf on the side of the screen; and change the wallpaper, which brings up the Wallpaper app. Image files saved to the Downloads folder can be set as a wallpaper by right-clicking them and choosing the appropriate option. Beyond this, there isn't much personalisation, apart from changing the picture that appears by your account name.

Extensions and apps

Remember that important issue we told you about? The first thing you should do is open the Chrome Web Store and install the Keep Awake extension [Image B]. When that's done, set it to Sunny Mode, which stops your Pi from going to sleep. The developers of this Chromium fork haven't quite worked out the Pi's sleep system,



Meet Chromium OS

1. LAUNCHER
Pop this up to search, or choose from recent apps.

2. SHELF
Not a dock. You can choose which apps appear here in Settings.

3. RIGHT-CLICK MENU
Get some basic app controls with this pop-up.

4. QUICK SETTINGS
Wi-Fi, Bluetooth, volume, power – they're all under here.

5. SETTINGS APP
Make changes to your Chromebox here, but don't expect great depth.

6. THE BROWSER
The full Chrome browser, with extension support. You'll spend a lot of time here.

and if it goes to sleep it won't wake up again. Or if it does, the keyboard input doesn't work, and you can't type your password.

Browse the Web Store and see if there's anything else you need to install – the Chrome Web Store is packed with extensions, though not all of them are compatible. The image editor Polarr wasn't when we checked, but Photopea, which is reminiscent of Photoshop, runs fine, albeit with a large grey bar down the right-hand side. Graphic design app Canva works too [Image C].

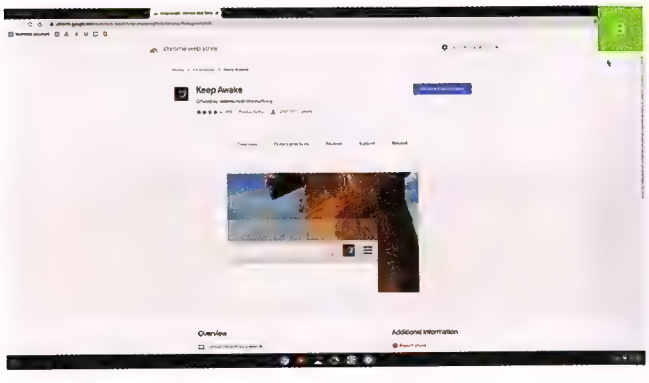
YOU'LL NEED
Raspberry Pi
3, 4, or 400
A MicroSD card
4GB or greater.

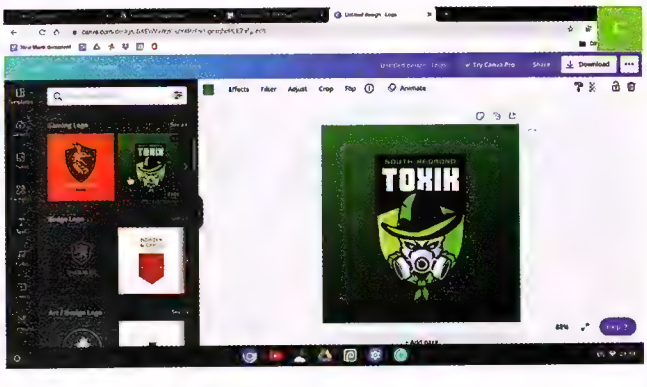
Google Docs

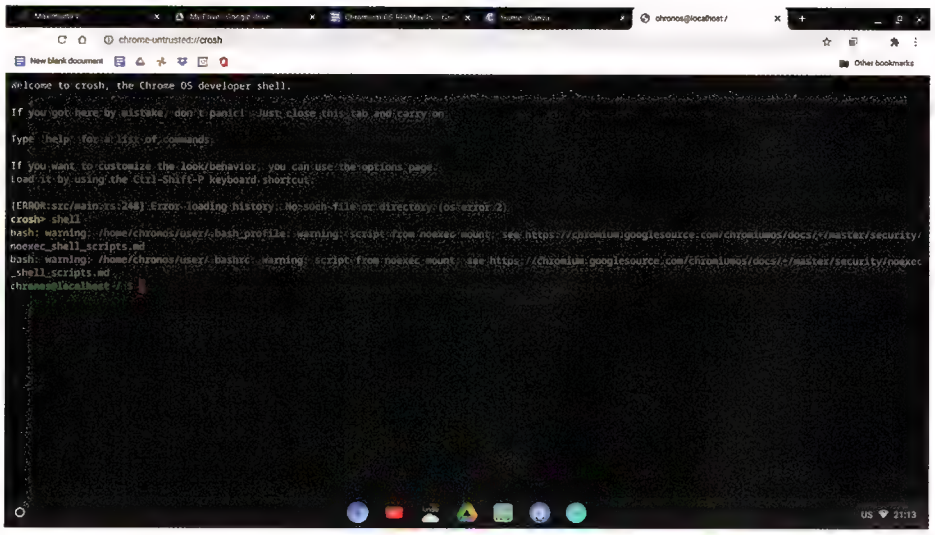
Working with Google Drive and Docs is exactly the same as in any other Chrome browser. Just open them in a new tab, and you'll get the familiar experience. We tried Microsoft Office Online too, and while it worked, it was an altogether slower experience. A Chromebox is very much an online entity, with little local storage, so you'll need to get used to storing documents in the cloud – especially as there's such a small amount of local storage included. If you find you need to increase the amount of storage available to the Chromebox, you can expand the filesystem to the full size of the card through the developer shell. Press Ctrl-Alt-T from the desktop, and a browser tab will open containing crosh. Type "Shell", and you'll be in Bash [Image D]. Type "sudo rm /mnt/stateful_partition/.autoexpanded" and reboot the OS.

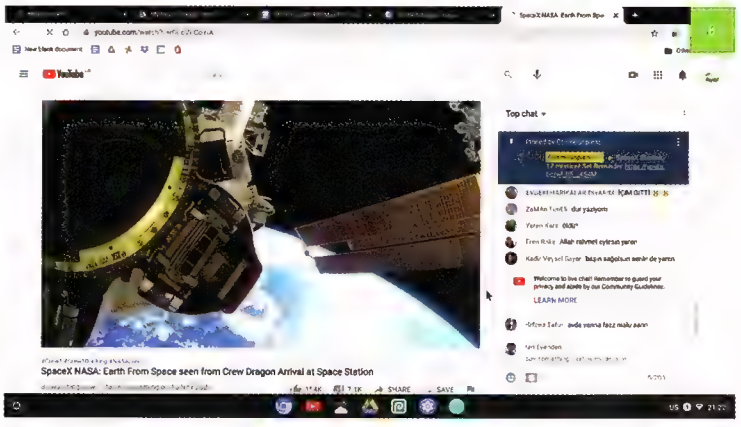
Media

You'd expect browser-based streaming services to be accessible through Chromium OS, but they're






chrome-untrusted://crosh
Welcome to crosh, the Chrome OS developer shell.
If you got here by mistake, don't panic! Just close this tab and carry on.
Type 'help' for a list of commands.
If you want to customize the look/behavior, you can use the options page.
Load it by using the Ctrl-Shift-P keyboard shortcut.
crosh> shell
chronos@localhost / $



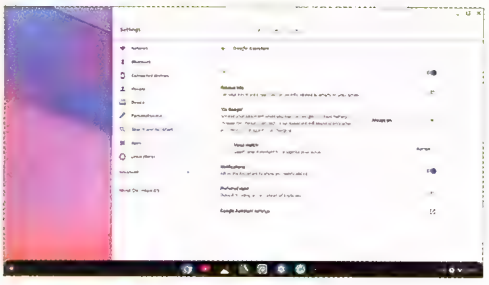
hit and miss. Being a Google project, YouTube is of course prominent, and we were able to watch a SpaceX capsule arrive at the International Space Station live and without jerkiness [Image E]. Attempting to watch hilarious Eddie Murphy movie 'Coming to America' on Amazon Prime, however, failed on every attempt with an unhelpful error. 'The Matrix Revolutions' failed in the same way, but admittedly felt like less of a loss. This was due to the Widevine DRM system for Chrome not being supported in Chromium OS. There's a way around it, which is linked to from the "Issues" page of the Chromium OS for Raspberry Pi Github.

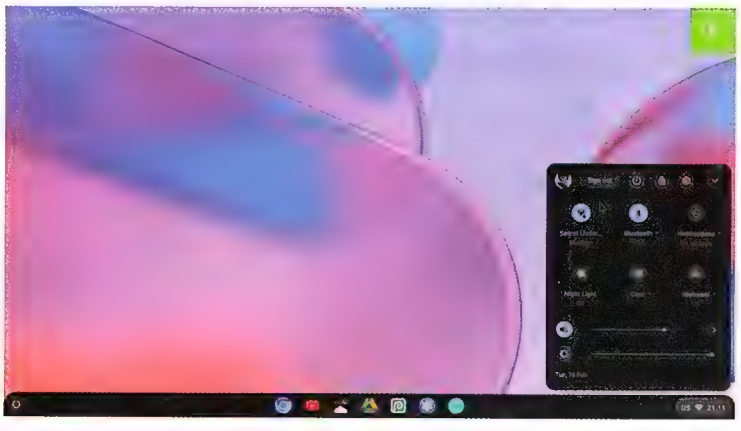
Settings and shortcuts

The Settings app is the blue cogwheel icon in the dock, and opens into a comprehensive set of options for your device. It's where you go to connect to a new Wi-Fi network, add a new user to the Chromebox, or pair a new Bluetooth device, as well as adjust the screen resolution and scaling. On a 4K display, we found things much easier to use if we boosted it up to 175 percent of the usual scale. Settings also contains options for personalisation (see the box) and, under the "Apps" heading, you can choose which apps are pinned in the dock. Some, like Photopea, open in their own windows, while others, such as Google Drive and Canva, open in a browser tab.

Quick settings and power

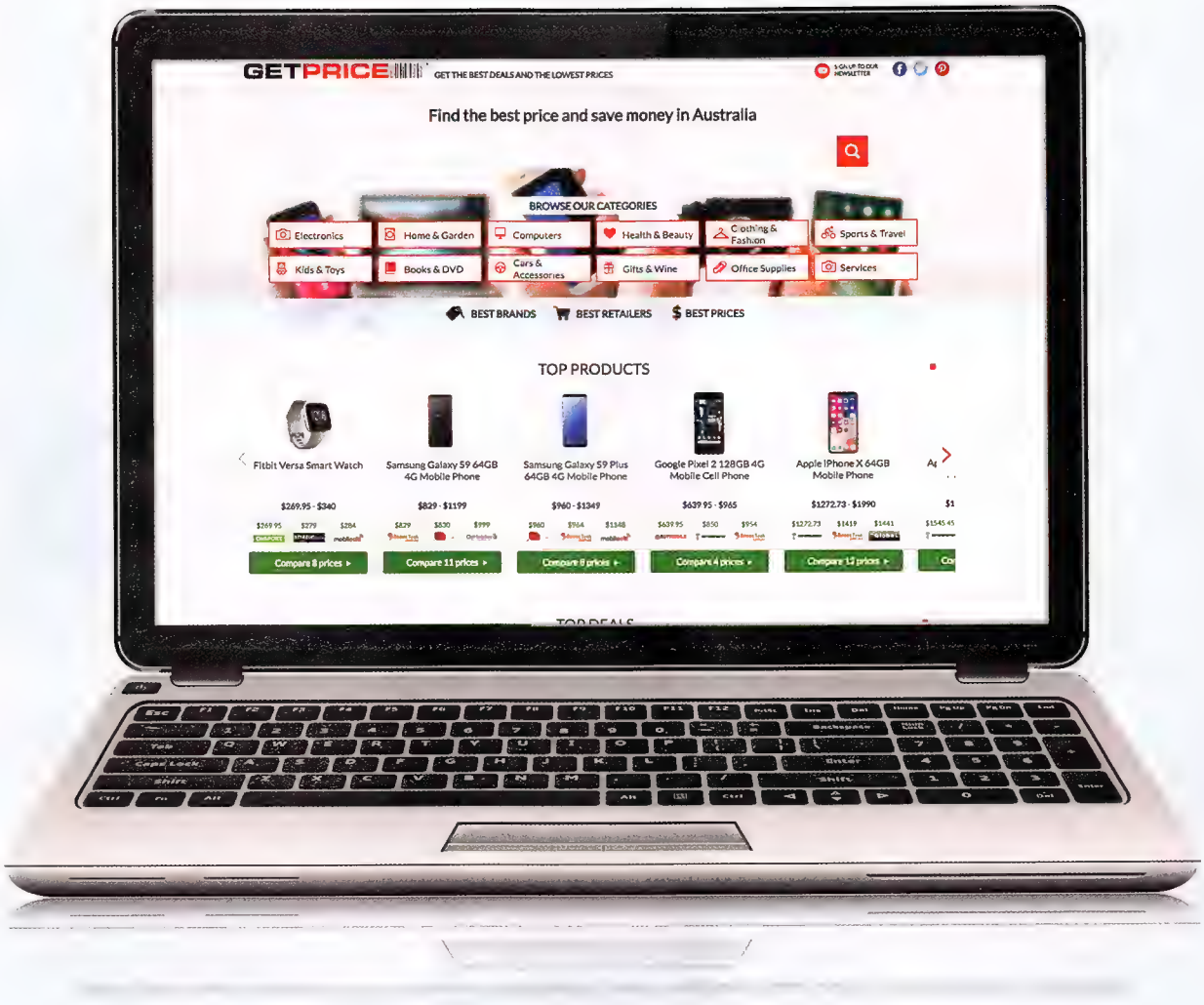
Click the grey lozenge at the bottom-right corner, and you'll get a pop-up menu with quick settings, such as turning Bluetooth on and off, changing the volume, locking the screen, and turning the system off [Image F]. Being a Raspberry Pi, the unit does not have the ability to switch itself off, so you'll have to cut the power yourself once the OS has finished shutting down. Most Raspberry Pi kits come with a handy switch on the power supply lead for this purpose.





Further adventures in settings

You can connect a mouse or touchpad to the Pi. Touchpad use is almost exactly the same as in Windows. Tapping with two fingers gets you the right-click menu, and scrolling involves dragging two fingers down the pad. If you want to reverse this, there's an option in "Settings > Mouse," from where you can also adjust the pointer speed. Pressing the Windows key brings up the Launcher, from where you can choose between recent applications or search for a new one, and there's a circle button in the bottom-left corner that does the same thing. "Settings > Keyboard" contains a great many options for mapping a Windows keyboard to the Chromebook standard, enabling you to change the behavior of Ctrl, Alt, Esc, Backspace, and more. Finally, Google Assistant can be activated, but is off by default, as Raspberry Pis don't have a built-in mic. Add one, plus speakers, and you can turn your Pi into a digital assistant.



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50 years of the microprocessor

In March 1971, Intel delivered the world's first microprocessor, the 4004. Fifty years on, Darren Yates looks back at the origins of a feat that would go on to change the world.

It's still pretty amazing to think that when astronaut Neil Armstrong stepped foot on the moon on July 20, 1969, he got there with a navigational computer having less processing power than an Arduino Uno makerboard. However, that same year, a Japanese business machines maker and a fledgling U.S. chipmaker would embark on a project that revolutionised computing forever – the Intel 4004 CPU.

Just another calculator?

During the 1960s, if you coveted the latest in technology, you had an all-electronic calculator. Forget adding machines and slide rules – the calculator was the 'iPhone 12 Pro' of the day and many well-known big-name brands were churning them out – Casio, Canon, Sony, Toshiba, Sharp, IBM, along with a smaller player that would go on to have a bit to do with computers in the 1980s called 'Commodore'.

However, back in the '60s, calculators were the size of desktop computers. IBM's first 608 calculator from 1955 is described as being available for 'commercial installation', such was its size (**tinyurl.com/4t8pmffc**). Nevertheless, the electronic valves that powered them were progressively replaced by smaller and vastly-more power-efficient transistors. Quickly, calculators went from being 'installed' to taking pride-of-place on the office desk – they were still a while away from slotting into your pocket.

By 1969, Japanese business machines maker Busicom wanted to launch a printing programmable calculator. Its chief engineer, Masatoshi Shima, had developed a 12-chip solution for the job but Busicom didn't have the capacity to make it. So, it called on a small U.S. chipmaker. At that time, Intel had only been in business for a year but had already begun fabricating RAM chips. Intel engineers looked at the Busicom design and came up with a more efficient four-chip solution designated 'MCS-4'.

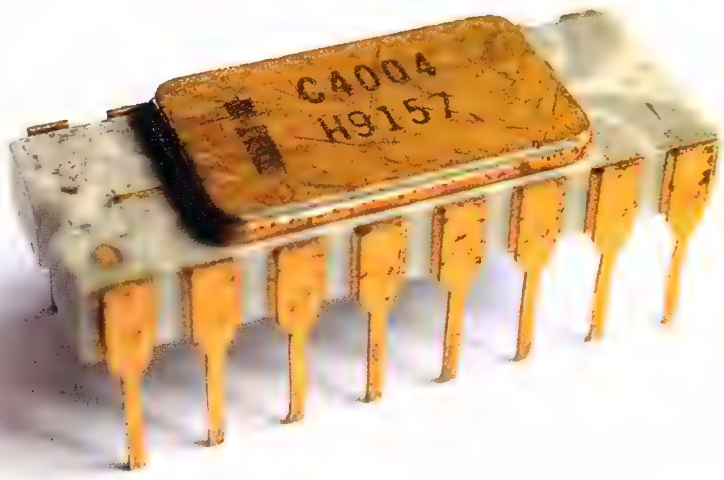
The four-chip solution consisted of the 4001 ROM (read-only memory) chip, the 4002 RAM chip, the 4003 contained various shift-register functions while the 4004 housed the core 4-bit central processing unit. Featuring 2,300 transistors, the initial 4004 had a 108kHz (0.108MHz) clock speed and eventually sold for $200 per unit.

Intel nearly lost the microprocessor

That clock speed sounds positively glacial by today's standards, but Intel was on the cusp of a revolution – and it knew it. The 4004 CPU could be applied to a myriad of other applications. There was only one problem – it didn't own the rights to its own design. Busicom had paid Intel US$80,000 the year before to develop the solution and had exclusive rights to the 4004 design. Realising the situation and the 4004's potential, the chipmaker quickly offered Busicom its US$80,000 back in return for rights to the 4004 for non-calculator applications. It no doubt became the source of regret for Busicom that it said 'yes' to the deal and the rest is now history. Despite selling the first calculator with a microprocessor chip brain, sadly, Busicom's fortunes quickly faded. Masatoshi Shima, the Busicom engineer, had left to join Intel in 1972 and Busicom struggled during the global recession of the mid-1970s, going bankrupt in 1974.

The 4004 was originally designed for Busicom's 141FP printing calculator.

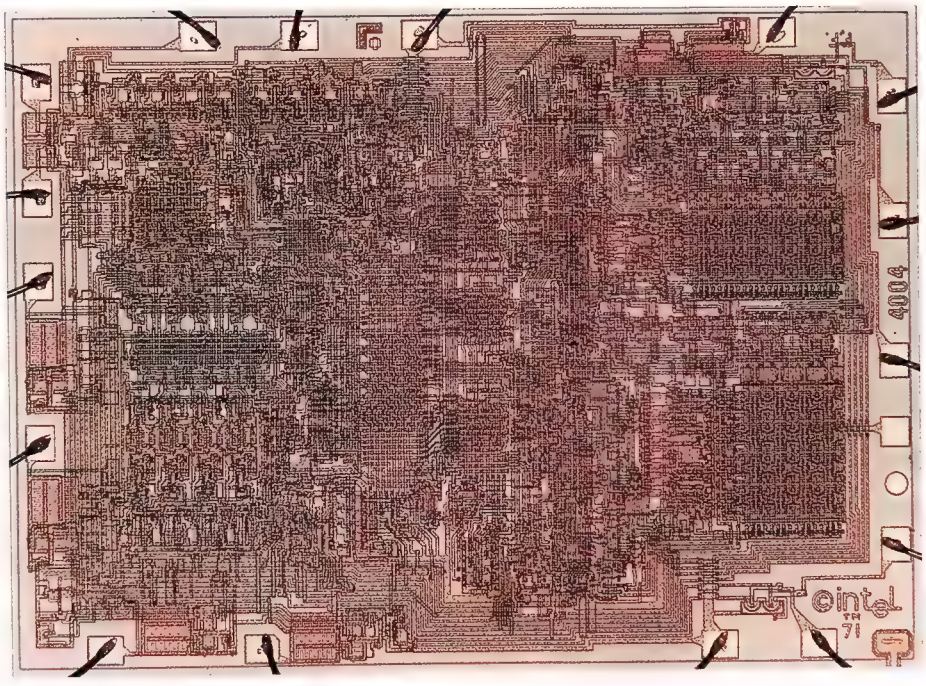
Intel 4004 designer, Frederico Faggin, in 2011 (source: Intel).



The Intel 4004 was the world's first microprocessor chip (source: Thomas Nguyen, CC-BY-SA 4.0).

Who designed the 4004?

But who invented the Intel 4004? Well, no story about something so world-changing would be complete without a whiff of controversy. While Masatoshi Shima came up with the initial design, Intel engineers Marcian 'Ted' Hoff and Stan Mazor reduced the design complexity and developed what would become the Intel 4004 architecture. However, neither of them could



The die of the 4004 microprocessor chip with its 2,300 transistors.

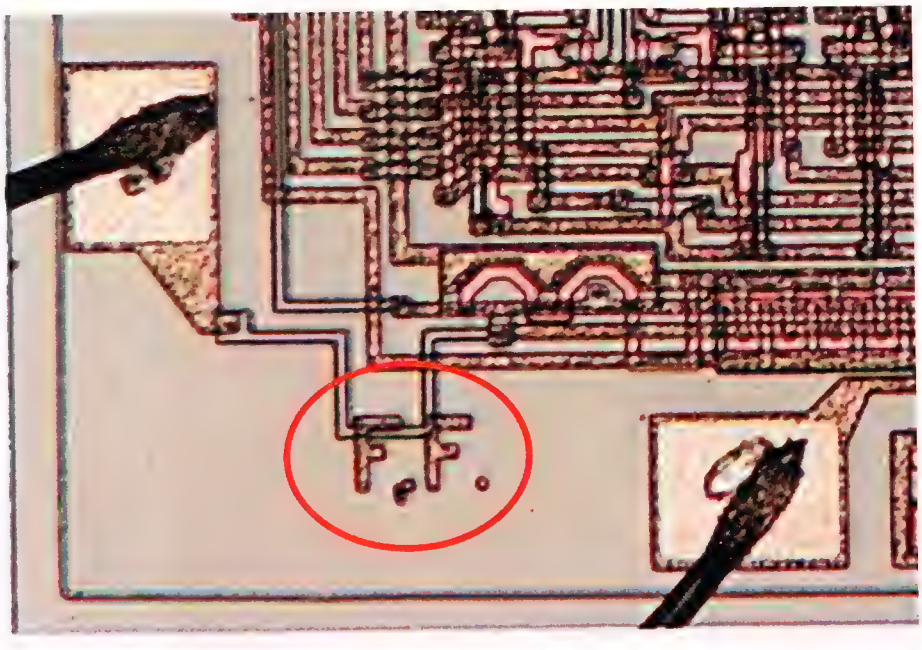
design the physical chips. At that time, Intel had just started producing new dynamic RAM chips, but a single-chip CPU was still outside its wheelhouse and by April 1970, the project had stalled (much to Busicom's annoyance).

The first single-piece or 'monolithic' integrated circuit (IC) had been invented by Intel's Robert Noyce in 1959 while working for Fairchild Semiconductor and by the end of the 1960s, the world was awash with ICs, including the popular 7400 TTL logic series. However, an integrated microprocessor was something no-one had yet successfully developed. It was another young Fairchild engineer newly employed by Intel, Frederico Faggin, whose task it was to get the MCS-4 project back on track. Not only did he possess the chip design skills Hoff and Mazor lacked, Faggin had recently jointly-invented a new type of metal-oxide silicon (MOS) transistor that would make higher-speed chips a reality. As head of the MCS-4 design team, Faggin had the four-chip design completed in just six months, with the first chip wafers arriving in January 1971.

Nevertheless, despite the success, the relationship between Faggin and Intel eventually soured and in 1974, Faggin left to launch start-up company Zilog to design and make microprocessors. This included the influential Zilog Z80 that powered many iconic computers of the 1980s, from the Sinclair ZX Spectrum and Tandy TRS-80 to Australia's own MicroBee. There are claims Faggin was 'disowned' by Intel after his departure to launch Zilog, however, time heals many wounds and in 2012, an Intel newsroom story credits him as the 'designer of the world's first microprocessor' (**tinyurl.com/w469uyjf**).

Regardless, Faggin's name is etched into history, literally – a small 'F.F.' appears in the 4004 die layout image and is etched into every 4004 chip.

Faggin etched his name into history – and his initials into every 4004 chip.



The revolution begins

The first production 4004 chips were made in March 1971 and after its deal with Busicom, Intel launched the 4004 publicly with great fanfare on November 15, 1971. By the time of its production, the Intel 4004 clock speed had risen to 708kHz (0.78MHz). Nevertheless, work continued apace and the following year, Faggin and his team had doubled the design, launching the 8-bit Intel 8008 in April 1972 and the more advanced 8080 in 1974. Intel continued its CPU adventure following Faggin's departure, with the Intel 8086 arriving in 1978, followed by the 8088 in 1979. This chip would be chosen by IBM to power its new 'personal computer' platform, with the IBM 5150 PC in 1981.

The wheel turns

Today, microprocessors have become so ubiquitous, we rarely give them a second thought. They drive our PCs and laptops, but we also wear them in our pockets, on our wrists and fit them into our ears. However, thanks to the power of machine-learning, microprocessors today help us solve problems as varied as boosting rice production to making vaccines. While quantum computing continues to show promise, our daily lives will continue for some time to come to rely on the microprocessor technology birthed 50 years a go this year. Happy 50th, Intel 4004. ■

Although largely forgotten by retro gamers, the Commodore 128 supercharged the C64 and still outsold many rivals.

MACHINE OF THE MONTH

Commodore 128

Emulating a piece of history, writes John Knight.

So far we've been covering home computing's big hits, but we also want to highlight some of the more under-appreciated computers, in the hope that we can generate more interest toward these retro machines.

This month we're covering the Commodore 128, the underrated follow-up to the phenomenal Commodore 64. Although there's plenty of business and desktop software for the machine, very little exists in the way of native games or demos.

We hope to change that. The Commodore 128 provides a great opportunity for any C64 coders who want to enhance their existing titles with extra features and content.

After we take you through a brief history of the machine, we will show you how to emulate it. With any luck we can inspire you to learn the machine's workings, and go on to code new games and demos!

Development

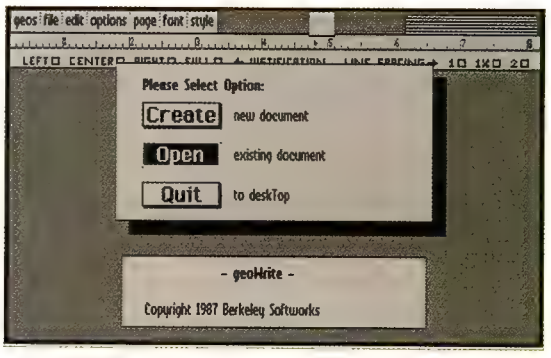
Commodore's final eight-bit machine, the C128, was developed as a halfway point between the Commodore 64 and the Amiga, intended to capture sales in the low-end business market. For the follow-up to the C64, Commodore listened to the demands of the press and stuffed the 128 full of features.

System RAM doubled to 128KB. There were two CPUs: a MOS Technologies 8502 – an improved version of the C64's 6510, capable of twice the clock speed – and a Zilog Z80 CPU, the processor that ran many of the C64's rivals.

A number pad was added to the keyboard, along with an 80-column text mode. The 128's BASIC was significantly improved, with more advanced programming structures, making the most of the 128's doubled RAM capacity. There was also a machine-language monitor and an in-built sprite editor, allowing freehand drawing of sprites that could be stored on disk.

The 128 had more reliable disk drives that were 11 times faster than the C64's, with double-sided heads, removing the need for disk-flipping. Furthermore, the new drives could read other formats, such as MS-DOS, and had automatic disk booting, so users no longer had to enter load commands in BASIC.

Crucially, the 128 was 99 percent backwards compatible with the Commodore 64 and its enormous software library. Thankfully the 64's legendary 6581 SID sound chip was unchanged.



Although the C128 wasn't a popular games machine, it was a well-loved desktop when paired with GEOS 128. © 1986, Berkeley Softworks.

What was it like to use?

From a gaming perspective, underwhelming, but from a business perspective, great. The 128 was focused on desktop productivity. Without hardware sprites or raster interrupts, the 80-column VDC chip was all business and not much use for gaming. On the upside, the new version of BASIC had graphical improvements, removing the need for POKE commands, and enabling users to easily create sprites.

Gaming was basically left to the machine's C64 compatibility mode, which could be accessed by holding down the Commodore key at startup, entering "GO 64" at the BASIC prompt, or starting the machine with a C64 cartridge attached. After the 128's release, most Commodore 64 games were

SPECIFICATIONS **CPU:** MOS Technology 8502 @ 1-2MHz **RAM:** 128KB **Launch price:** $595 **Graphics:** VIC-II E 320x200, 16 colours, MOS 8563 640x200, 16 colours **Sound:** SID 6581 **Storage:** Cassette, 5.25in floppy, 3.5in floppy, and cartridge **OS:** Commodore BASIC 7.0, Digital Research CP/M 3.0, GEOS 128 **Released:** January 1985 **Production:** 1985-1989 **Worldwide sales:** 5.7 million.

Games like *Thai Boxing* (1986) were part of the small list of games that used the 128's native mode, rather than using C64 compatibility. © wikipedia/evan-amos, 1986, Anco Software Ltd.

Find software

We generally point to **archive.org** first, but there's not much actual C128 software. However, it is full of user guides, programming manuals, and BASIC program listings if you're willing to get stuck in and write something new.

For actual software sources, a great place to start is the "C-64 Scene Database" at csdb.dk. Enter "128" in the search box, and you can find a good listing of games, demos, and utilities for the 128. Anyone looking specifically for demos should check out **https://demozoo.org/platforms/55/**. There are some games thrown in as well, with some software as new as 2020.

However, the best resource has to be the forums at **c-128.freeforums.net**. Here you can find new games and demos, and chat all things Commodore.

Commodore 128 software usually comes on disk, though these files are unhelpfully still given the extension ".d64" – don't mix your 64 and 128 files into the same folder!

advertized as being "Commodore 64/128 compatible."

When running in C64 mode, most of the 128's extra functions were disabled, though the machine's 2MHz CPU mode was still available, and some games took advantage of this ability, like Elite 128. Games that used the 128's native mode often enhanced existing C64 titles with extra levels and content, such as *The Last V8* (1985) and *Kikstart 2* (1987). *Ultima V* (1988) added a soundtrack and used the 128's faster disk access. Many titles were simply text adventures that took advantage of the 80-column mode.

Weirdly, the 80-column mode required a second monitor, though Commodore released a special monitor with dual inputs and a switcher for choosing modes.

YOU'LL NEED

ALMOST ANY PC

Very little. Almost any PC will be catered for, we'll focus on Windows and Linux. You won't need any system ROMs – the emulator comes with a BIOS.

VICE

https://vice-emu.sourceforge.io/

Down to business

Thanks to its Z80 CPU, the 128 was CP/M compatible – a long-established software ecosystem popular with businesses. Unfortunately, the 128 ran most CP/M software slower than other systems, meaning its CP/M compatibility was largely ignored.

Instead, 128 owners preferred GEOS 128: a graphical desktop originally created for the C64, but greatly enhanced for the 128, using its extra power and features. GEOS was similar to macOS and came with productivity tools like a word processor and paint program. The 128 version used a high-resolution 640 x 200 display mode, helping establish the 128 as a serious business machine.

By the time the C128 was discontinued in 1989, it was no longer economically viable to produce. Manufacturing costs were too close to the Amiga 500, and cost-reduced models of the C64 were still selling strongly, especially in Europe.

With 5.7 million units sold worldwide, the 128 never reached the dizzying sales of the Commodore 64, but it was still a success in its own right and outsold most other microcomputers.

How do I emulate it?

Our main choice of emulator is VICE, which supports Windows, Linux, Mac, and many obscure platforms. VICE is known primarily for emulating the C64, but supports all eight-bit Commodore machines, including the 128.

For the Windows version, head to the website and download the latest build. This package uses the 7-Zip format, so you may need a separate application for that. VICE doesn't come with an installer, so after extracting the package, you'll have to go into the new folder, open the bin folder, and manually open x28.exe. You might want to make a desktop shortcut.

For Linux users, VICE is available in the repositories but will probably be missing key "kernal" files due to licensing restrictions. You can get these files from a source tarball, but it's much easier to install a Snap or Flatpak package instead. Both versions should install entries in your system menu.

Snap users can find the package on the Snapcraft store under the name vice-jz. If you prefer Flatpak, you can install VICE with the command:

```
$ flatpak install flathub net.sf.VICE
```

Usage

As soon as VICE-128 is opened, the first thing that hits you is a two-window setup: one is for the older C64 40-column display, the other is for the newer 80-column display.

The old 40-column display is used for the initial load commands, but then a native 128 title may switch to the high-res display. Meanwhile, the 40-column display will give you a message to switch to 80-column mode – with VICE that just means switching to the other window!

The easiest way to load something is by clicking "File>Smart attach disk/tape." Choose your file, and click "Autostart." If you get stuck with the BASIC prompt saying "LOADING, READY," type "RUN" and press Enter.

Before you get started on any games, you should define how you will use joysticks: whether they be keyboard emulated, or by an external device. From the system menu, choose "Input devices>Joystick settings." You need to define the method for two ports: most games use joystick port 2, so whatever you intend to use most, set that keyset or joystick to use port 2, and have your backup on port 1. Don't forget to save your configuration by clicking "Settings>Save settings."

If you encounter any 3.5in floppy images (which may have a .D81 file extension), you'll need to change the type of disk drive. From the system menu, select "Settings> Settings>Peripheral devices>Drive." Make sure "True drive emulation" is enabled, and change "Drive type" from the default setting of CBM 1571 to CBM 1581. ■

Disco Elysium banned in Australia

THE NARRATIVE DRIVEN RPG INCENTIVISES DRUG USE.

Another game has fallen afoul of the Australian Classification Board, and this time it's a game that Aussie PC users have been able to buy and play for years. In the lead up to its late March '*The Final Cut*' reissue, which adds voice acting and a slew of other quality of life improvements, the board has refused classification.

Like several other games that have received an RC ruling, *Disco Elysium* features drug use as an incentive, though factors such as addiction, crime, cruelty and violence were also listed by the board.

While the original game was not manually assessed by the board due to being a digital only PC release, the *Final Cut* is due for release on consoles and also a physical editions. If you already own the game on PC, you'll still be able to access it in Australia.

Riot begins recruitment for *League of Legends* MMO

THE PROJECT IS REAL, BUT IT MAY BE A WHILE OFF.

A Riot executive offhandedly confirmed on Twitter earlier this year that a much requested *League of Legends* MMO has been given the green light, and thanks to some recruitment notices we now have a little more detail on what that will entail. According to a new website at **worldofruneterra.com**, Riot is after talent adept at gameplay engineering, game design, UX design, game art and game production.

"No, you're not dreaming, we're working on an MMORPG based in the *League* universe!" the site reads. "We know MMOs take a lot of people to create, and we'll need a pretty big raid team if we want to bring Runeterra to life. That's where you come in. We'll periodically post new roles, but right now we don't have any specific openings on the team – we're just gearing up for the journey (and need to replace our greens first)."

GAMING NEWS

The director of *Anthem* has left BioWare

Jonathan Warner is "moving on to new things".

The director of *Anthem* and *Mass Effect: Andromeda* has left BioWare. Jonathan Warner announced the news on Twitter last month. "So, today is my last day at BioWare, I'm moving on to do new things," Warner wrote. "BioWare has been home to my grateful heart for nearly 10 years and I want to wish them all the best."

Publisher Electronic Arts and BioWare announced in February that they will cease development on *Anthem*, which launched in early 2020 to widespread negative criticism. A plan to reinvigorate the live service loot shooter was also abandoned in February, with BioWare focusing on new *Dragon Age* and *Mass Effect* games.

In addition to his work on *Anthem* and *Andromeda*, Warner is also credited as a director on the original *Mass Effect* trilogy, which receives a remaster this month.

Microsoft may buy Discord

...but Discord could choose to go public instead.

Discord is reportedly considering a sale, and according to a Bloomberg report last month, Microsoft is in line to acquire the platform for more than US$10 billion. This follows similar reports that the game chat company is "exploring its options" for a sale, and that "multiple parties" are interested.

Don't get too excited for another bombshell acquisition though, because one of Bloomberg's sources said that Discord will likely go public rather than sell. It also notes that Discord has had discussions with Epic Games and Amazon in the past.

If another company does acquire Discord it'd be a good strategic get, though the company itself has acknowledged in the past that it's not profitable. As of December last year it could boast 140 million active users per month, while last year its valuation reportedly doubled from US$3.5 billion in June, to US$7 billion in November.

Discord is ubiquitous among gaming communities and is usually preferred to first-party alternatives offered by the likes of Sony and Microsoft, not to mention Steam and Epic Games. The chat service also rebranded itself in 2020, severing some of its overt ties to videogames in favour of a more "general purpose" public image.

"It's easy to get tunnel vision and zero right in on Horizon Zero Dawn as the star here, but if you have a PSVR headset and haven't played Astro Bot Rescue Mission yet, oh my."

Horizon Zero Dawn will be a free PlayStation Play at Home game in April

Plus *Astro Bot Rescue Mission* and more next week.

The next round of free PlayStation Play at Home titles are on the way, including your chance to nab *Horizon Zero Dawn Complete Edition*.

Before Aloy joins the program this month, you'll be able to claim nine free games. The selection represents indie favorites from across PS4 and PSVR, and they're all live now. Here are the regular PS4 games, all of which are playable on PS5 as well through backwards compatibility: *Abzû, Enter the Gungeon, Rez Infinite, Subnautica, The Witness*

And here are the free PSVR titles, which are also playable on PS4 and PS5 – though you will, of course, need a PSVR headset.

Astro Bot Rescue Mission, Moss, Thumper, Paper Beast

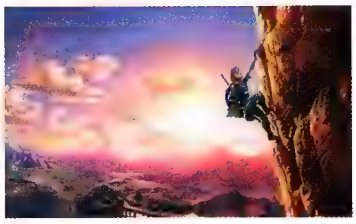
This slate of games will be available to claim through April 22, and they'll overlap just slightly with *Horizon Zero Dawn*, which will be available from April 19 to May 14. It's easy to get tunnel vision and zero right in on *Horizon Zero Dawn* as the star here, but if you have a PSVR headset and haven't played *Astro Bot Rescue Mission* yet, oh my. You are in for a delight.

Dying Light 2 devs reaffirm 2021 release window

Techland has released a brief *Dying Light 2* teaser that ends with four numbers: 2021.

Little else was revealed in the latest *Dying Light 2* update, but we did get a few moments of gameplay and... some sort of Mean Tweets style montage of the devs reading off profanity-laced complaints from impatient fans. The devs also talked briefly about when we can expect more info, directing fans to the game's Discord where they can submit questions for an upcoming Q&A.

At the end of the video, the 2021 release window flashes across the screen. Though, there seems to be some confusion about whether the devs were saying the game is releasing in 2021 or if they just meant more info is coming this year. Personally, I would hope it's a given that we'd at least hear from the devs on *Dying Light 2* this year, which is why I'm pretty sure they're reaffirming to a 2021 release window here.



Legend of Zelda: Breath of the Wild looks even more breathtaking in 8K with ray tracing enabled

The Legend of Zelda: Breath of the Wild has been upscaled to 8K with ray-tracing enabled by a YouTube channel that specialises in applying next-gen graphics and photorealistic visuals to modern games. The channel responsible for making Hyrule look so beautiful is Digital Dreams (**tinyurl.com/APC493ZEL**), who have also upscaled other games including Immortals *Fenix Rising* at 8K, and *Star Wars Battlefront 2* with photo-realistic visuals.

Ghost of Tsushima devs worked "nonstop for six years" to perfect combat system

While speaking at a virtual AMA session during the GDC Showcase, Sucker Punch's Brian Fleming was asked which *Ghost of Tsushima* feature was the most difficult for the team to work on. "Easy answer and the answer is combat. The combat system was something that the team that worked on that – the handful of programmers and designers and animators – you know they worked nonstop for six years and built multiple versions of it with multiple approaches." ■

$19.99 | PC, Mac, Linux | loophero.com

Loop Hero

This charming micro RPG is one of this year's first true gems.

From the moment its 16-colour title screen fades in alongside dramatic chiptunes, *Loop Hero* feels like some forgotten, VGA-era fantasy RPG, a game that contains the mystery and difficulty of 1991, gently modernised to 2021. Behind that charming intro screen isn't empty, indulgent nostalgia, but a novel gameplay format that's strangely engrossing, considering much of your time playing *Loop Hero* is hands-off. I want more games like this.

The setup is dead-simple: you send one of three heroes (warrior, rogue, or necromancer) on repeated expeditions to an empty road. As your little hero auto-walks around this stone path, you populate the blank world around it by playing cards like graveyards, battlefields, villages, or mountains one by one. These pieces in turn alter hero or enemy stats like attack speed and HP, and spawn corresponding enemies that you fight as you pass through them.

Each run essentially becomes a small experiment, another crack at piecing together a level that's tough enough to give you good XP, resources and gear but not so brutal that it kills you outright. What happens if I play a bunch of spider cocoons and sand dunes, which lower all creatures' HP? What will river cards do if I intersect them with the road itself? Can my warrior survive two adjacent tiles filled with giant sandworms?

Loop Hero is about tending this little gauntlet. It's unexpectedly fun to have zero control over combat and worry mostly about arranging these little tiles. My favourite design element within *Loop Hero*'s build-your-own-dungeon concept are the hidden effects that trigger when you play certain cards. Drop nine mountain cards in a 3x3 grid and they transform into a massive Everest-like peak, granting a mega boost to max HP. But, surprise: harpies now live in the mountain you built, a challenging enemy type that will fly down to a random part of your board every few days.

Loop Hero is the concentrated experience of watching numbers get bigger in a videogame, but it's a grimly enchanting one. Its biggest point of success is that it makes a home in this middle zone between watching, planning, and acting. Supporting each and every moment is some excellent music and sound design – scraping slashes, a giant mosquito's buzz, the clattering sound of a skeleton reanimating. This is the sort of smart, focused resurrection of old games I want more of, something that feels retro and new with every expedition step. I managed to put more than 40 hours into this quote-unquote small game.
EVAN LAHTI

Loop Hero has the spirit of early '90s fantasy games, cleverly revived in an original and digestible form.
★★★½☆

$54.00 | PC, Mac | strongholdwarlords.com

Stronghold:Warlord

Can it rebuild the foundations of the series?

The original *Stronghold* holds a special place in my heart. You build a medieval barony, surround it with a labyrinth of impassable walls, and stave off waves of attackers while keeping the serfs living within happy, well-fed, and well-taxed. It had real character too, with a lovely soundtrack, snappy unit soundbites and memorable villains.

Stronghold: Warlords feels a million miles away from that game. It's the most sprawling entry series in the yet – largely abandoning the principle of building a feudal gauntlet for waves of enemies in favour of a more traditional RTS setup featuring larger maps and symmetrically placed enemy bases.

The warlords system is the twist here. Beyond your base and the enemy's, there are several smaller estates on the map held by neutral warlords. Defeat these warlords and they'll join your side, sending you resources on demand, offering mini-forts to shelter your troops, and even launching attacks on your enemies.

It's a decent idea in principle but falters on a couple of levels. Firstly, it means that your main keep doesn't see a ton of action. Most of your time in a skirmish match will be spent scuffling over these warlord forts that you don't have any hand in building except for preset upgrades. You buy these upgrades with diplomacy points, which you can also use to buy a warlord's loyalty. The system gets

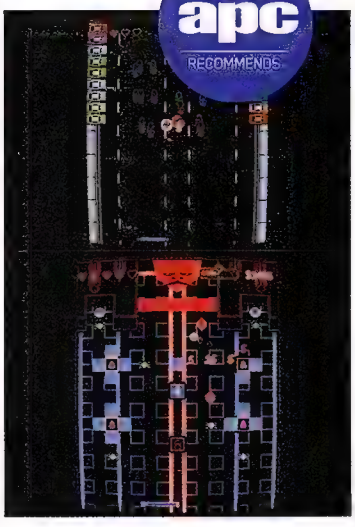
very messy in the late game as you and enemies get embroiled in an endless diplomatic tug of war by throwing your points at warlords to win their fleeting loyalty.

The actual warfare works much better. Siege equipment is varied, ranging from trebuchets to kamikaze oxen to a rudimentary medieval rocket launcher, and watching a city burn before funnelling your troops into it remains one of gaming's crueller pleasures. Familiar melee, cavalry, and ranged troops are joined by Far Eastern classics like samurai, warrior monks, horse archers, and ninjas. It's a solid roster, making combat tactically richer than earlier games while retaining some of the series' trademark whimsy.

ROB ZAK

A decent strategy game that lacks the big personality and siegecraft that made the original special.

★★★☆☆



Free | PC | bit.ly/LocustUSA

Locust, U.S.A

Breaking new ground *Stranger Things*-style.

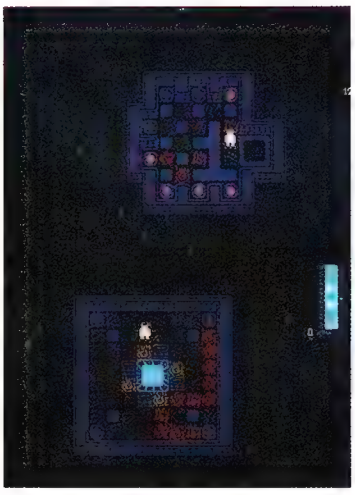
Basically, this is *Breakout* but *Stranger Things*, with every stage of the game themed around a creepy high school or facility, and with sumptuous synths warbling over the top. You're still trying to whack blocks with a paddle and ball, but here those blocks are joined by enemies and switches, collectible coins, and letters that spell out 'LOCUST' (that's the name of the town). Every one of the handful of levels is markedly different, in location and layout, but also in its objectives – although you're generally trying unlock/bust open a door, and then go through it. Interstitial bonus stages offer the chance to improve your score, while random events keep things interesting by doling out boons, or occasionally curses, multiple times during each level.

The theme of this is such fun. *Stranger Things* is the primary flavour, but there's also a dollop of '80s horror movies, and a big, *Tron*-shaped crouton at the top of the pot. I suppose that sounds a bit messy, but it just means that every stage is surprising – right up until the abrupt cliffhanger ending.

TOM SYKES

A great theme and solid innovations make this a worthy play for fans – and non-fans – of *Breakout*.

★★★★☆



Free | Browser | shmoozey.itch.io

Overflow

Water works in a creative puzzler.

Overflow is a game about sloshing water around in a bucket. You play as a cute little gardener attempting to water a bunch of plants, while trying to avoid watering the weeds placed all over the ground. There's also a well that gradually fills, before overflowing with water. If that happens, you'll fail the stage and have to restart.

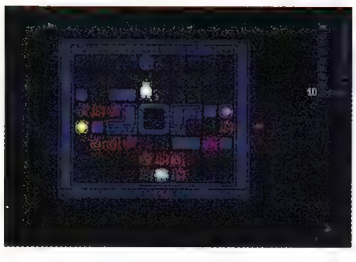
This is a little more complicated to grasp than many block-pushing games – there are no blocks, and no pushing for that matter, but it's the same grid-based puzzling beneath the surface. The difference being the bucket, which allows you to ferry water from the well to all the thirsty, thirsty plants, but that will also leak onto every other tile you visit. If you step on a weed while carrying water, it will turn into a movement-blocking bush on the next turn, and that's clearly a bit of a hindrance in a game like this.

Every single action matters here. You have to be extremely careful over your order of movement, although levels are short enough that restarting them is not really that much of a big deal.

TOM SYKES

A quietly inventive puzzler that will perk you up on a dreary afternoon.

★★★½☆



$27.95 | PC, PS4, XB1, Switch | focus-home.com

Curse of the Dead Gods

A sharp and atmospheric roguelike dungeon crawler.

Curse of the Dead Gods takes many cues from traditional action adventure games, and benefits from them enormously. The most obvious one is probably the fact that the game is essentially split into levels. The first temple tier contains three 'levels', with three more tiers and a total of seven more levels above that. Each completed level is permanently marked with a satisfying green tick. It's a sign of achievement and progress, which is an important part of player feedback that many roguelikes fumble.

Combat is brilliant, another example of more traditional influences. Though familiarly dependent on stamina points, it has a speed and flow that ensures battling the horrors of the temple is always a joy. Each time you pass through a door leading to a new area, you gain 20 corruption. Hit 100, and you gain a random curse, a twist on play that makes things more difficult for you.

It's difficult to lay out the rules of the game, as the developers take such delight in regularly rewriting them. This partly comes through the curses, which might encourage you to embrace the dark rather than shy away from it, or ensure you have at least 300 gold when passing through a door or pay the difference in health. The rarer buffs and weapons meanwhile have their own spins on the experience, such as reducing the corruption inflicted when passing through a door, or increasing your damage according to how many relics you're carrying. After a few hours, you'll start to see the same room layouts creeping in, but it always feels fresh.

Randomness plays a strong part in the experience – it's still a roguelike – but you're given the opportunity to slightly nudge things in the direction of your choice. You can spend your persisting currency to expand and dictate your choice of starting weapons, and even gain tokens to reroll what's on offer at the shrines you encounter during each run. It's a welcome element (illusion?) of control.

LUKE KEMP

A perfect introduction to roguelikes, or a hugely enjoyable and unique adventure for veterans of the genre.

★★★★☆

$28.95 | PC, Linux | nepos.games/nebuchadnezzar

Nebuchadnezzar

A capable city-builder, but one that becomes less fun as it goes on.

A city-building throwback that throws players all the way back to the cradle of civilisation, *Nebuchadnezzar* arouses fond memories of games like *Caesar III* and, to a lesser extent, *Age of Empires*. Its classical style both looks and sounds great, while its systems delve deeper than what is apparent on the surface.

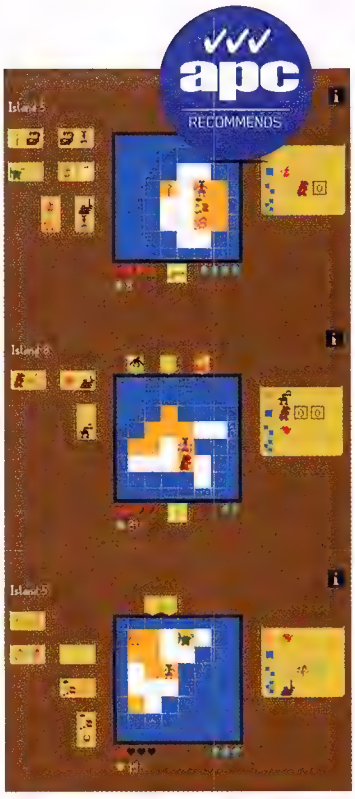
Unfortunately, as *Nebuchadnezzar* grows in scope, it becomes increasingly burdened by micromanagement, while a couple of significant design flaws threaten to sink the whole enterprise. Set in ancient Mesopotamia, *Nebuchadnezzar*'s campaign tasks you with building some of the world's oldest and greatest cities – Ur, Nineveh, Babylon, etc. Guided by Gilgamesh through the game's four introductory missions, the remaining nine levels involve constructing thriving metropoli, capping each one off with a great wonder such as Ashurbanipal's Library, the Hanging Gardens of Babylon, or your own custom-designed temple complex.

Successful city management involves mastering logistics and production chains, as well as catering to the ever-increasing demands of your populace. There are three different classes of citizen, each of which lives in a different building type that also has multiple stages of evolution. Regular workers will begrudgingly reside in a half-finished hovel. But supplying these houses with bread and milk will upgrade the house, enabling more workers to live in it.

Unfortunately, the deeper you delve into the game, the more stressful the experience becomes. Establishing distribution routes for your market vendors becomes a chore in any settlement. Not only must you establish a new route for every vendor in the city, you'll also have to alter the route whenever you add buildings to that area, which you do constantly. It can be difficult to identify problems within your production chain.

There's much about *Nebuchadnezzar* to appreciate, from its wonderful presentation to its dynamic city simulation. But the core systems are too stern and austere compared to the payoff of successfully building your city. It isn't lacking for class, but really needs to dial up the fun factor.
RICK LANE

City-building fun is hindered by micromanagement and trading issues.
★★★☆☆



Free | PC, Mac | captaingames.itch.io

Castaway on a weird island

Deciphering paradise found.

You're a castaway on a desert island – or should I say islands, as you're forever leaving one blob of rock for another filled with hidden enemies and power-ups. Ignoring all that stuff at the screen borders for a moment, you can just uncover each tile randomly, by blundering into a scorpion, or a skeleton, or a restorative spa with the mouse or arrow keys, before you either find the raft and progress, or you die. That would be fun enough, I suppose, but those borders are actually a veritable trove of information.

That pile of icons on the left informs you of enemies and objects that are adjacent to one another, though not where exactly they're located in the world. The icons at the top tell you, 'this thing is in this column somewhere', while the table on the right lists any objects near the sea, and how many aquatic tiles are surrounding them. So that's three types of clues to jumble satisfyingly in your head, though you're never given quite enough to eliminate the need for guesswork.
TOM SYKES ■

A heady concoction that's kept me returning time and again.
★★★★☆

Now that's dynamic lightsaber combat.

DEVELOPER BIOWARE **PUBLISHER** LUCASARTS **RELEASED** 2003 **WEB** bit.ly/starwarsknights

Star Wars: Knights of the Old Republic

Andy Kelly revists the RPG from a time when *Star Wars* is everywhere.

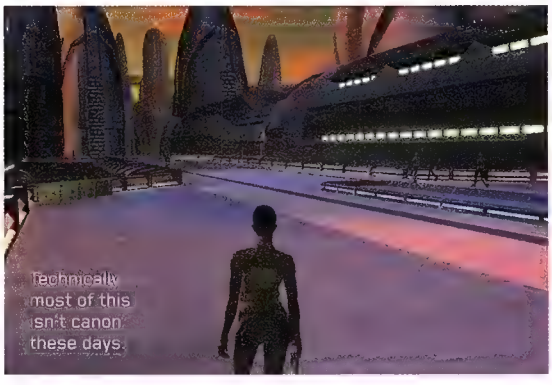
Like many people, I recently finished season 2 of *The Mandalorian* and was left with a hunger for more *Star Wars* in any form. I rewatched the original trilogy, read a selection of graphic novels and books (including Steve Perry's brilliant *Shadows of the Empire*), and – and best of all – decided to replay BioWare's classic *Star Wars* RPG *Knights of the Old Republic*.

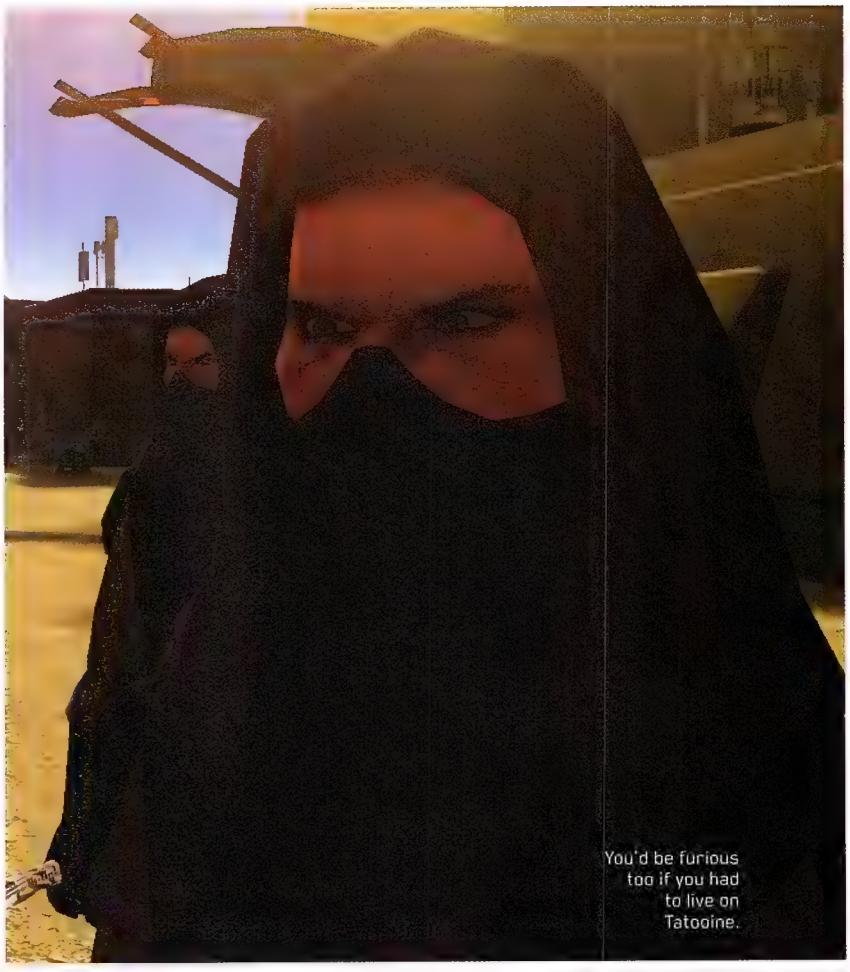
The last time I played *KOTOR* was around the time of its release in the autumn of 2003, and it was the perfect antidote to the disappointing prequel trilogy. George Lucas was two films deep by this point. *Attack of the Clones* was released the year before and I was not a fan, to put it mildly. But here was this videogame, set 4,000 years before Luke Skywalker, Darth Vader, and the Death Star, reminding me of why I loved *Star Wars* in the first place. A rare, thrilling chance to explore the ancient, unseen history of my favourite fictional universe.

Today, after years spent drifting in the pop culture Dune Sea, *Star Wars* is in a very different place. A whole new film trilogy has been and gone, along with several spin-offs. The series successfully made the jump to the small screen, including the aforementioned *Mandalorian*, which is the most I've enjoyed a *Star Wars* thing in ages. And owner Disney just recently announced a galaxy's worth of new movies, books, and TV shows. Honestly, it's a bit much.

The Force Awakens landed so perfectly because it had been years since the last good *Star Wars* film. *Rise of Skywalker*, by most accounts, did not – not only because it was a cowardly retcon of *The Last Jedi* and ultimately just a bad, confused film, but because people were sick of *Star Wars*, at least in its traditional form. I went to a midnight screening of *Awakens*, and I didn't even bother seeing *Rise* on the big screen. They lost me. So as much as I enjoyed *The Mandalorian*, which reignited my passion for the series in a big way, I wondered if by installing *KOTOR* I was at risk of reaching *Star Wars* overload once again.

But what sets BioWare's game apart, even after all this time, is where it sits on the timeline. Most of the *Star Wars* stories being told today revolve around the Skywalker clan and other events from those nine films. Even *The Mandalorian*, which did a good job of carving its own path through this galaxy, succumbed to the temptation – particularly in the latter half of season 2. But by throwing you back to the days of the *Old Republic*, *KOTOR* gives you a fresh perspective on this





universe, letting you witness its rich and storied history first-hand.

Golden age

When the game begins, the Republic is at war with the Sith, led by the evil Darth Malak. The Jedi have been left scattered and vulnerable, with many turning to the Dark Side and joining Malak's growing army. And that's where you come in, a hero with a mysterious past who joins the dwindling Jedi Order and embarks on a quest to stop Malak and his powerful Sith fleet. Those are the broad strokes, but things get a lot more complicated – especially when the protagonist learns, in a very *Star Wars* plot twist, a shocking truth about their shadowy past.

Of course, there's the question of canon. It's a great story, but did it 'really' happen? Another big change that occurred between *KOTOR*'s release and now is that the events of the game may no longer be part of the main *Star Wars* continuity. When Disney snapped up *Star Wars* it categorised this game, and countless other *Star Wars* spin-offs from the so-called expanded universe, as 'Legends'. That said, some things BioWare created for *KOTOR* – the planet Taris, card game pazaak, and the Selkath race, to name just a few – have appeared in projects that are considered canon. So the whole situation is a little unclear. There's also a rumour that screenwriter Laeta Kalogridis is working on a *KOTOR* movie for Disney, so maybe this story, if the film sticks closely to it, will be canon after all.

Really, though, it doesn't matter. Just because the classic short story anthology *Tales of the Bounty Hunters* is as non-canon as it gets doesn't mean it isn't still a fun collection of *Star Wars* yarns. And even though we now know it was *Rogue One*'s Jyn Erso, not Kyle Katarn, who stole the plans for the first Death Star from the Empire, *Dark Forces* remains a superb *Star Wars* game. Some fictional universes benefit from a consistent, traceable timeline, but *Star Wars* is like a myth, a fairytale, and that makes this less important.

PARTY ON
Best to worst companions

CARTH ONASI
Soldier, hero, nice guy, handy with a blaster.

HK-47
Assassin droid who despises all organic life.

BASTILA SHAN
Powerful Jedi, knows her way around the Force.

MISSION VAO
Tough-willed teenage Twi'lek with an attitude.

CANDEROUS ORDO
Cranky Mandalorian with a very large gun.

JOLEE BINDO
Wry old Jedi who straddles the Dark and the Light.

ZAALBAR
Likeable Wookiee, but never has much to say.

JUHANI
Kinda boring Jedi you can save from the Dark Side.

T3-M4
Astromech droid with no actual personality.

Mandalorians weren't always as stylish as Pedro Pascal.

The Ebon Hawk is very much a proto-Normandy.

About to drop the freshest album this side of the Rim.

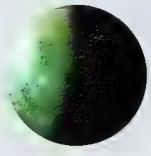
Who really knows what happened 4,000 years ago? *Knights of the Old Republic* is just one possible version of those events.

However, despite the chronological gulf, *KOTOR* still has plenty to scratch any *Star Wars* itch you might develop. If anything, BioWare made its take on the universe a little too similar to classic *Star Wars* – especially considering the amount of time that's supposed to have passed between this game and the original trilogy. But I'll let it slide, because the established language of *Star Wars* – blasters, speeders, astromech droids, cocky smugglers, pious Jedi, and so on – lays a familiar foundation to tell this new story on. BioWare could have created something completely different and alien, and I'm sure they would have done a great job of it, but it might not have felt very *Star Wars*.

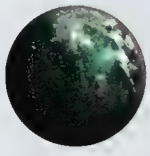
And even though some of the lore has since been contradicted by Jon Favreau and Dave Filioni's TV show, a heavy Mandalorian presence makes *KOTOR* particularly enjoyable if you've just finished watching the adventures of Din Djarin and his tiny green Force-sensitive friend. At this point in time the Mandalorians have just lost a war, scattering their clans around the galaxy. You run into a few of them, including a gladiator named Bendak Starkiller (no relation to the hero of *The Force Unleashed*), and Sherruk, the powerful leader of a gang of raiders who loves nothing more than killing Jedi and collecting their lightsabers as trophies.

You also party up with a Mandalorian: a grouchy war veteran named Canderous Ordo, whose Dark Side alignment makes him an ideal companion for anyone role-playing as such. And if you're not, then he always has a sarcastic remark ready when you follow the Jedi Code and deny a reward for doing a good deed.

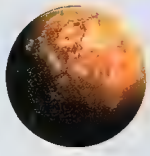
OUTER WORLDS
A selection of the planets you visit in KOTOR



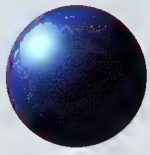
DANTOOINE
A quiet, remote world where the protagonist learns the ways of the Jedi, and tests their new lightsaber out on a group of Mandalorian raiders.



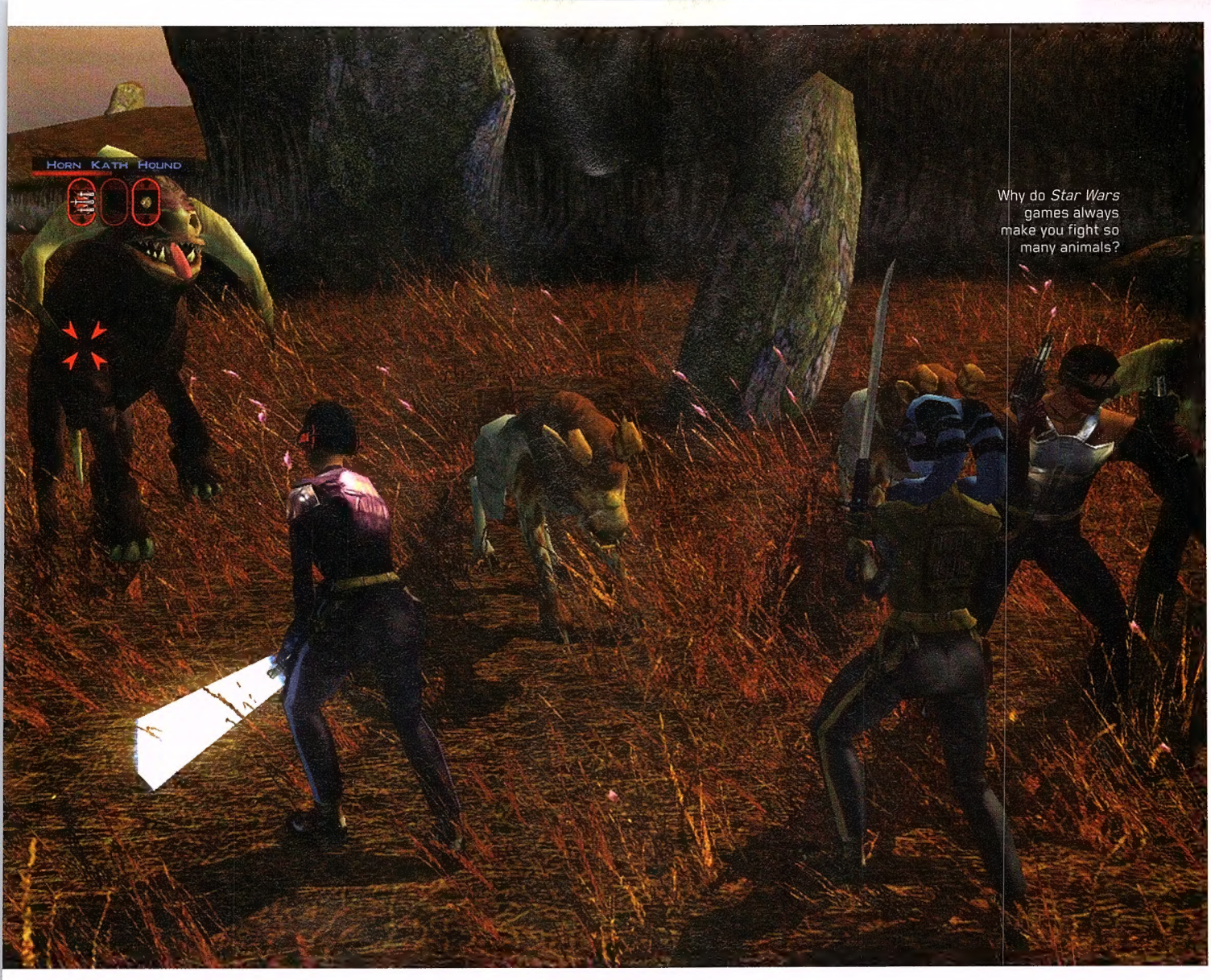
TARIS
A planet-sized metropolis. The upper city is safe, relatively speaking, but the dangerous lower levels are ruled by crime-loving swoop-bike gangs.



TATOOINE
A barren desert world you may have heard of before. When the protagonist arrives, the Czerka Corporation has laid claim to the planet.



MANAAN
A vast ocean-covered planet. The protagonist visits its capital where they uncover an evil Sith plot to brainwash children who are Force sensitive.



Why do *Star Wars* games always make you fight so many animals?

Turning down credits gets him particularly hot and bothered. I also really like BioWare's take on what Mandalorian armour might have looked like thousands of years ago. It's actually quite different, but the T-shaped visor is a nice visual link to the Beskar gear that we're used to seeing being worn by the likes of Boba Fett and Bo-Katan.

Outer space

And like *The Mandalorian*, most of KOTOR is set in the Outer Rim – the wild, remote, often lawless part of the galaxy where all the best *Star Wars* stories take place. Taris, the first planet you visit, is like a rougher Outer Rim take on Coruscant – a planet-sized metropolis plagued by crime and ruled by ruthless swoop bike gangs. You also get to visit the quiet agrarian planet of Dantooine, which Princess Leia mentions briefly in *A New Hope*, and find it besieged by Mandalorian raiders looking for something to do now that they don't have a war to fight. And, of course, there's a stop at Tatooine, the most significant planet in the entire *Star Wars* mythology, whose desert surface is being strip-mined by the Czerka megacorporation.

But is it still fun to play? *KOTOR* regularly makes lists of the best *Star Wars* games, but I often wondered how much of that was fuelled by nostalgia. So I was glad to discover that, while rough around the edges, it remains a great RPG. The environments are nicely varied, with compelling self-contained stories relevant to each world's politics and history. The personal journey of the hero, and how they handle that big revelation, is well written and emotionally impactful. The companions are memorable; both in their interactions and how they respond to your decisions. It's still clunky, with a messy UI and stiff animation, but the challenging combat, reactive quests and strong writing absolutely hold up.

It's also interesting, as a *Mass Effect* fan, to see the genesis of that series here. The first *Mass Effect* is basically a refinement of *KOTOR* minus the *Star Wars* stuff. Flying between planets, chatting with companions aboard the Ebon Hawk and facing tough moral choices in quests, I can't help but think of Commander Shepard and the gang. *KOTOR* is BioWare's first really successful transition from 2D games like *Baldur's Gate* to three dimensions. Although interestingly, the combat is still rooted in *Dungeons & Dragons*, borrowing its d20 system – although the developer does hide this here more than it does in its Infinity Engine games.

And the good news is, it runs fine on modern PCs. To play in higher resolutions you'll need to do some modding, so check out the game's entry on the PC Gaming Wiki for instructions. It's worth reinstalling, even if you're burned out on *Star Wars*. *KOTOR* is detached enough to still feel like a fresh take on the material – which is a weird thing to say about a game that came out when George W Bush was president. But with Disney still sticking closely to that familiar pool of characters and events, *KOTOR*'s distance from them is worth celebrating even more. ■

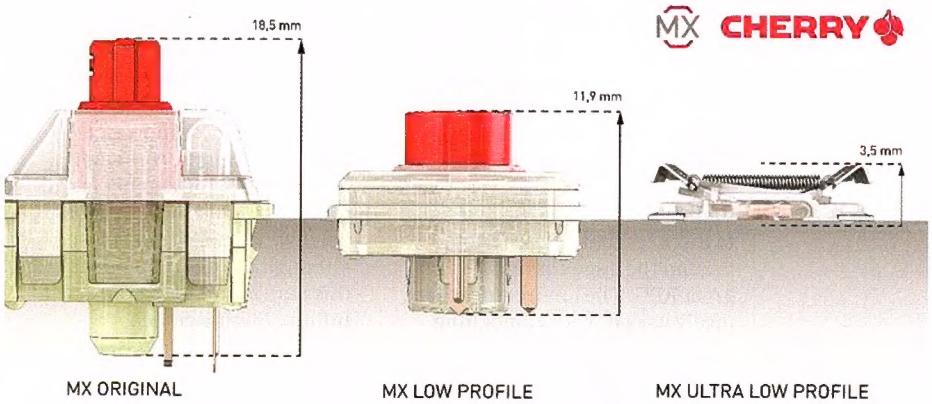
CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS

YouTuber puts *Tenet* on Game Boy to spite director

This isn't Christopher Nolan's first choice for watching the *Tenet* movie.

While artistic integrity is often broadly championed, Christopher Nolan's assertion that his film *Tenet* "really needs to be enjoyed in your theatres on the big screen" was perhaps a little tone deaf considering it arrived in the throes of a global pandemic. YouTuber Bob Wulff was so disgruntled by the comment that he dedicated hours to modifying the film for the smallest screen he could think of... the Game Boy Advance. The two and a half hour feature has to be split across five GBA cartridges and was shrunk to a 192x128 pixel resolution that runs at a not so buttery-smooth 6fps.



Cherry goes back to the future with new mechanical laptop switches

DeLorean wing-door inspired keys bring mechanical switches to gaming Ultrabooks.

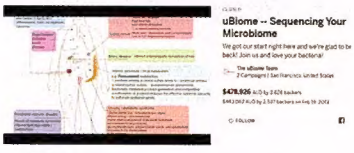
A three year partnership between Alienware and mechanical switch manufacturer Cherry has resulted in a new fully mechanical switch that is slimline enough to be used in a gaming laptop. The new MX Ultra Low Profile Cherry Red switch has a total travel distance of 3.5mm and was said to have taken design inspiration from the winged door action on the fabled DeLorean cars. The new keyboards will feature on Dell's Alienware m15 R4 and m17 R4 gaming ultrabooks, marking the first mechanical keyboards to become available on thin and portable gaming laptops.

Rachel True
@RachelTrue
Anyone else getting this error from Apple iCloud ? In past or now?
I'm 6 months deep freeze & looking for any help.
I rem dead coding languages like kobalt.. & this seems like an Apple coding issue — not hardware
iCloud has stopped responding.
An error has prevented this application from working properly. Help Apple improve its products by sending us diagnostic and usage information about iCloud.

Actor blocked from iCloud because of inappropriate name

HER NAME WAS 'TRUE'.

Actor and author Rachel True was locked out of her iCloud account for more than six months because her name was confusing the servers she was trying to log in through. True posted the automated response code "Type error: cannot set value to 'true' to property 'LastName" on her Twitter account to see if publicity might prompt Apple to fix the specific classification error that seemed to be exclusively affecting her (and perhaps Mr False). While many suggested it would be easier for the actress to change her name than rewrite the underlying code, True suggested that she may instead get a dog and call it Boolean Bobby Drop Tables to ensure all computers struggled to categorise it.



uBiome is full of it, says SEC

SOME EXPERTS HAVE COMPARED POO ANALISIS COMPANY'S DECEPTIONS TO THERANOS.

In March, the US Securities Exchange Commission charged the now bankrupt Silicon Valley gut health startup, uBiome, with defrauding investors. Both the company's CEO Jessica Richmand and her romantic partner, co-founder and uBiome Chief Science Officer Zachery Apte have been accused of lying about the financial position and medical capabilities of the product in order to secure additional funding. Both are facing charges of securities fraud, conspiracy to commit healthcare fraud, money laundering and other related offences that each have maximum penalties of up to 20 years prison time. The company got into financial trouble after insurance companies began clawing back payments for claims that used the same gut biome samples in multiple, allegedly unnecessary, tests. ■

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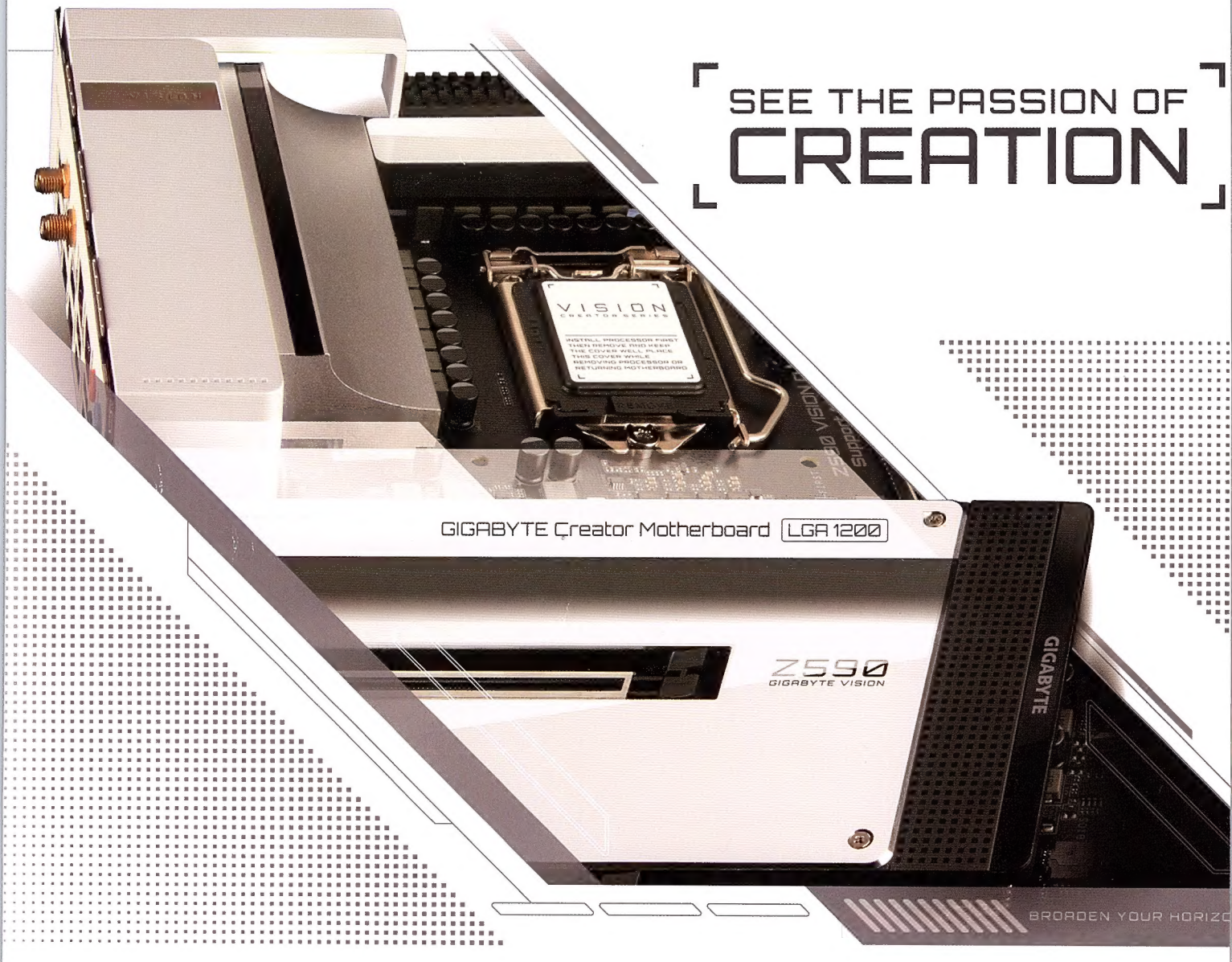

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